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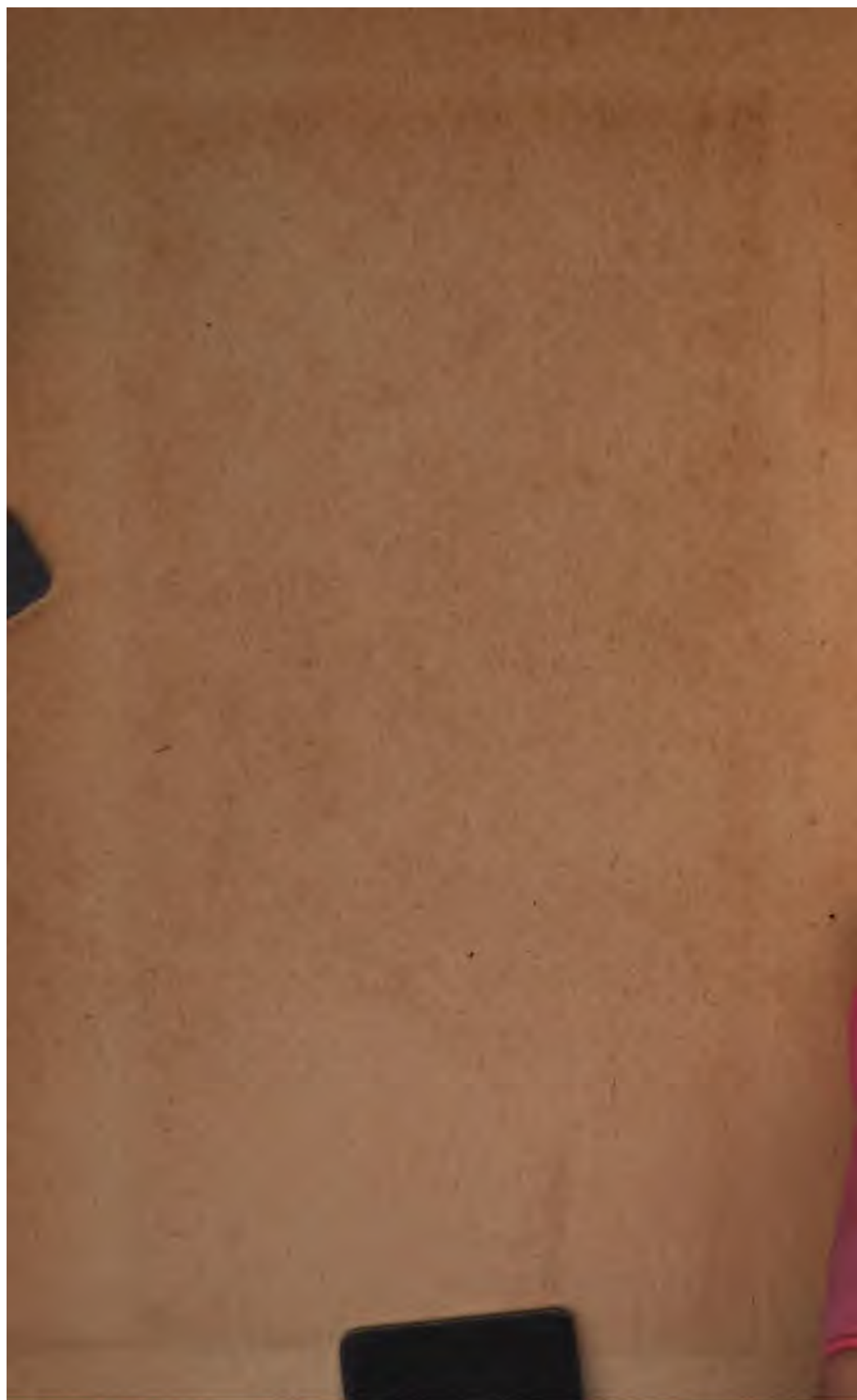
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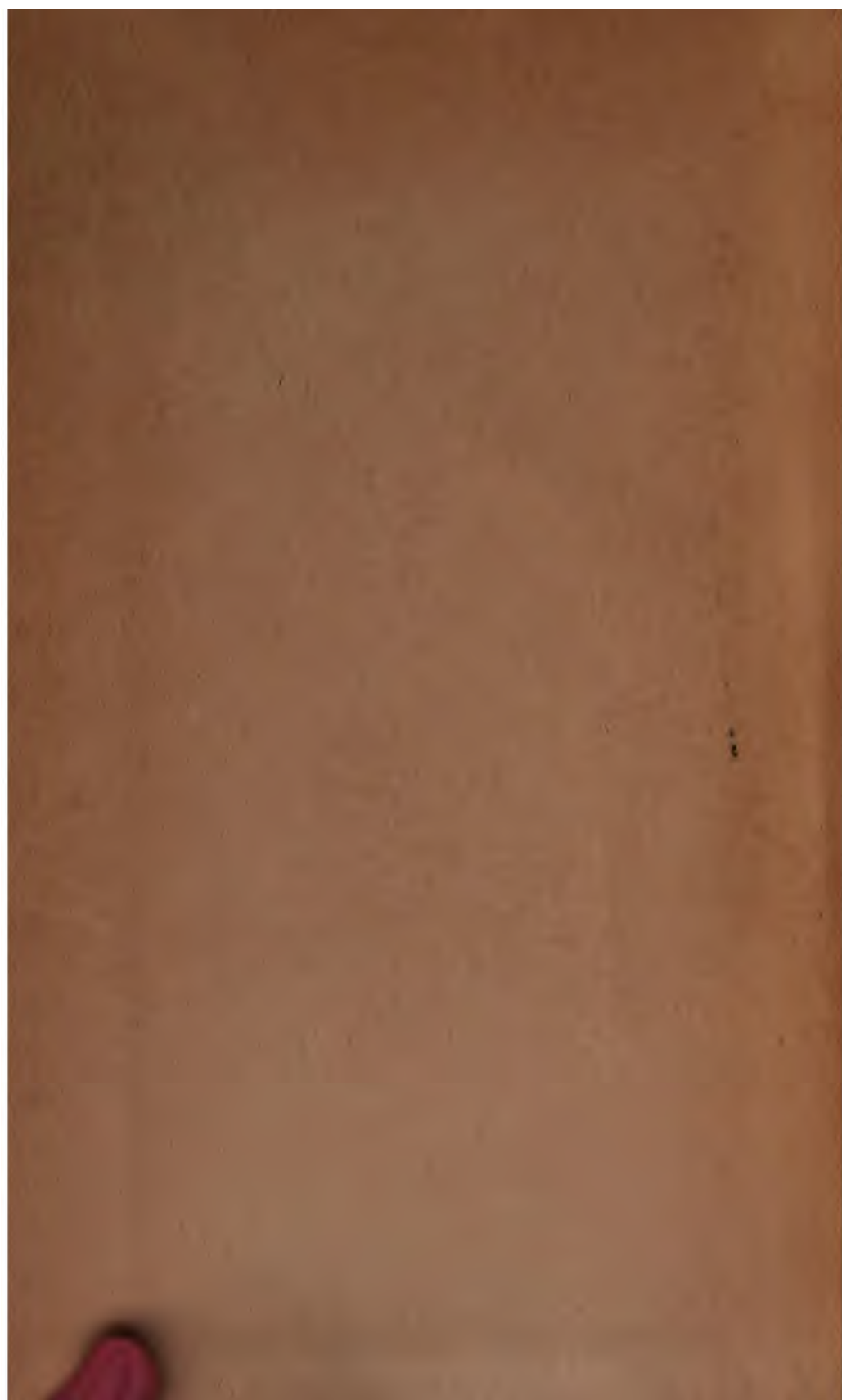
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ERRATA

- Page 275, line 5 from top, for Williard G. Van Name read Willard G. Van Name.
 " 295, line 12 from top (No. 8), for *Trididemnun* read *Trididemnum*.
 " 446, lines 20 and 22 from top, for *rubilabia* read *rubrilabia*.
 " 594, line 8 from bottom, for *magensis* read *nagaensis*.

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**Article I.—THE ANTERIOR CRANIAL ELEMENTS OF
ÆDIPUS AND CERTAIN OTHER SALAMANDERS**

BY G. K. NOBLE

PLATES I AND II

Having recently had the opportunity of examining the proof-sheets of an elaborate treatise on the lacrymal bone by Dr. W. K. Gregory, I was much impressed by the extreme difficulty experienced in determining just what has been the fate of the lacrymal in the various families of salamanders. This confusion arises in part from the fact that earlier accounts often give only meager details as to the lacrymal duct and its relation to the cranial elements. Many of the figures in the extensive accounts of Cope and Wiedersheim have no septomaxilla represented, although actually present in the species considered and of real significance. The exact structure of the skull of the salamanders is being utilized more and more to demonstrate genetic relations. My purpose in recording the following observations, mostly corrections of accepted ideas, is to facilitate future work on these relations.

THE CRANIAL STRUCTURE OF *Ædipus*

In 1869 Cope, reviewing the family Plethodontidæ, considered in detail the skull structure of the various genera but failed to find any differences between the skull of *Ædipus* and that of *Eurycea* (*Spelerpes* auct.). He (1869, p. 96) concluded that *Ædipus* differed from *Eurycea* "solely in the fatal non-separation of the digits." This difference until very recently was not considered worthy of generic distinction by most authors. No one since the appearance of Cope's paper has hitherto questioned his observations on the skull of *Ædipus*.

Very recently the name *Ædipus* has been arbitrarily applied to those neotropical salamanders having the digits fully or partly webbed. Thus

Dunn (1918, p. 470) states: "I use *Ædipus* provisionally for the salamanders allied to *leprosus*, *bellii*, *variegatus*, etc. These do not seem to be particularly close to [t]he species of *Eurycea* or *Pseudotriton*. Still less are they allied to the European *Geotriton fuscus*."

An examination of the skulls of three of the species of this group as defined by Dunn has convinced me that Dunn is confusing at least two distinct assemblages of forms and that Cope's statement as to their uniformity of skull pattern cannot be accepted. The name *Ædipus* should be restricted to one of these assemblages, while the other I consider identical with *Eurycea*. Very marked differences in the anterior cranial elements distinguish *adspersus* and *striatulus* from *leprosus*. *Ædipus variegatus*, the type of the genus, is so closely allied to *O. striatulus* (see Noble, 1918, p. 344) that it seems probable that these cranial patterns will be shown to be the same. The following characters common to *O. striatulus* and *O. adspersus* may be considered as the distinguishing features of the genus *Ædipus* as now defined: (1) no prefrontal; (2) no septomaxilla; (3) premaxillæ ankylosed only at their extreme anterior ends.

These three points of structure are important because certain of them are shared by other genera of Plethodontidæ and the question immediately arises whether or not *Ædipus* is more closely related to these other genera than it is to *Eurycea*. Thus *Geotriton* exhibits the first two points of structure but, as regards the third point, I find that its premaxillæ are entirely separate. Still, its small nasals and half-webbed digits distinguish *Geotriton* from *Ædipus*. It is more probable that the resemblance between *Ædipus* and *Geotriton* are due to parallel modification from a common ancestral stock, rather than to any close affinity between the two genera.

Ædipina, which on external features one would consider nothing but an elongate *Ædipus*, differs radically from that genus in its fused premaxillæ. From the statements of Cope (1869, p. 101) as to the reduced nature of its parietals one would then expect that *Ædipina* possessed a cranial composition very similar to *Batrachoseps*. In fact, *Batrachoseps*, with its almost boletoid tongue, might be imagined to be a side branch of the *Ædipina* stock. Unfortunately, the specimen of *Ædipina uniformis* which I dissected does not bear out Cope's statement. The frontal and parietal elements are but slightly reduced. This condition, together with the absence of the septomaxilla in *Ædipina*, readily distinguishes it from *Batrachoseps*.

The closest relatives of *Ædipus* cannot be determined at this time because of the lack of material. It is interesting to compare, however,

figures of the skulls of *Ædipus adspersus* and *Eurycea leprosus* respectively. One is tempted to say at once that the cranial pattern of *Ædipus* has been derived directly from that of *Eurycea* by three modifications: the fusion of prefrontals and nasals on each side; the loss of the septomaxilla; and the greater union of the premaxilla. Such is probably the correct view. A glance at the salamanders as a whole will show that parallel fusions and losses have occurred independently in many different genera and are not indicative of genetic relations. This was recognized long ago by Cope but Fowler and Dunn (1917) and Dunn (1918) have recently reviewed the subject and added many valuable suggestions.

THE ANTERIOR CRANIAL ELEMENTS OF OTHER SALAMANDERS

The question of whether a fusion of parts has actually occurred in *Ædipus* or whether both prefrontal and septomaxilla have simply dropped out involves the all-important question of homology. A comparison of Dunn's (1920, Fig. 1) figure of *Rhyacotriton* with my figure of *Ædipus* (Pl. II, fig. 2) will show an element having nearly the same relative position labeled prefrontal in Dunn's and nasal in my sketch. Four skulls of *Rhyacotriton* in The American Museum of Natural History have the element labeled prefrontal by Dunn much more extensive than he has indicated, in fact covering the area a nasal might be expected to cover.

The question of homology arises again in regard to the lacrymal. When present as a definitive bone, the lacrymal is characterized by the lacrymal duct. But such a definitive bone is commonly absent in the salamanders, the lacrymal duct not piercing any bone. In most plethodontids the lacrymal duct passes ventral and medial to the ascending ramus of the maxilla or ventral to a portion of the prefrontal and nasal. In *Plethodon cinereus* it passes entirely dorsal to the prefrontal. In *Ambystoma* it pierces the prefrontal.

It may be argued that the presence of the lacrymal duct marks the position of a potential lacrymal in *Ambystoma*. Ontogeny does not support such a view. In *A. opacum* up to 41 mm. total length, the anlagen of the prefrontal is without the lacrymal duct perforation. At 65 mm. the extreme ventral edge splits longitudinally and forms along its ventral margin a hollow tube. At this stage the septomaxilla is indicated by two splints of bony tissue less than a millimeter in length, lying along the anterior end of the lacrymal duct. The nasals are at this stage entirely unossified. Later growth carries the lacrymal duct farther toward the

center of the prefrontal. The nasals very soon make their appearance. It is evident from the series of larvæ before me that at no stage of growth is there a definitive lacrymal.

In my opinion, the only method by which we are going to arrive at any sound conclusion in regard to the fusion or the dropping out of the cranial elements is by a careful comparison of the crania of forms which both zoögeographical and morphological evidence show to be closely related. Thus it may be easily demonstrated that in the Plethodontidæ the prefrontal tends to diminish in size and may reasonably be assumed to drop out at the end stages of specialization. But the affinities of *Rhyacotriton* are not yet clear enough for us to state definitely with Dunn that the nasals and not the prefrontals have been lost. Its affinities with *Dicamptodon* are shown as much in its fourth toe having but three phalanges (not mentioned by Dunn) as it is by its distinctly different hyoid and skull structure. Until the skull structure of the short-toed species at present grouped under *Ambystoma* has been investigated we cannot be certain of the homology of the anterior cranial elements of *Rhyacotriton*.

Dunn (1920, Fig. 1) in figuring the anterior cranial region of *Rhyacotriton* has omitted the septomaxilla, or, rather, has drawn it as part of the lacrymal. The septomaxilla is a very distinct element, not only in *Rhyacotriton* but also in many salamanders which have been represented as lacking it. Its presence or absence should have as much morphogenetic significance as the presence or absence of the prefrontal. The structure and function of the septomaxilla in the salamanders has been recognized by many. Gaupp (1905, p. 746) has reviewed the subject briefly. There still remains to be pointed out the wide occurrence of this element in the salamanders, and the possible significance of its occasional absence. Material does not permit me at this time to go into the subject fully or do more than to indicate corrections to certain accepted figures.

The septomaxilla when present in the salamanders always tends to wrap around the anterior end of the lacrymal duct (Pl. II, fig. 1). It may be very small (Pl. I, fig. 1), a mere splinter, or it may have an expanded portion covering and supporting part of the nasal capsule. It is sometimes absent, apparently due to a crowding out by the ascending ramus of the maxilla or the nasal which have apparently shifted forward in some forms as in *Ædipus* (Pl. I, fig. 2 and Pl. II, fig. 2) and in *Geotriton*.

The majority of plethodontids possess a septomaxilla, although such an element has been often overlooked. It is not represented in the figure

of Wiedersheim (1877, Pl. xxv, figs. 104 and 105) of *Aneides lugubris* nor in those of Cope (1889, Pl. xxvii, figs. 1 and 2) of the same species. Still, in a specimen (A. M. N. H. No. 5350) in the American Museum there is a distinct septomaxilla lying in the usual position.

The elaborate figure of *Batrachoseps attenuatus* given by Wiedersheim (1877, Pl. xxv, fig. 94) is totally incorrect as regards the anterior part of the cranium. The old figure of Eschscholtz (1829, Pl. xxi, fig. 4) is a much better representation of the actual conditions. But Eschscholtz does not indicate the presence of a septomaxilla. It is a very large element in both *B. attenuatus* and *B. major*.

It has not hitherto been pointed out that in *Hemidactylium* the septomaxilla is a very large element, nearly as wide as the ascending ramus of the maxilla. It is in contact with the nasal, a rather unusual condition.

Cope (1889, Pl. xix, figs. 4 and 5) has omitted the septomaxilla from his figure of *Plethodon cinereus*. In all the species of the genus which I have examined it is present. The position of the lacrymal duct varies in the different species and, in correlation with this, the septomaxilla varies its position and contacts. Even in such closely related forms as *P. metcalfi*, *P. yonahlossee*, and *P. glutinosus* the septomaxilla does not have a constant relation to the surrounding elements.

All of the ambystomids which I have examined possessed a septomaxilla. Cope (1889, Pl. xvi) does not represent such an element in *A. maculatum*. Parker (1877) includes it in some of his figures of *Ambystoma* but not in others. Wiedersheim (1877) does not indicate it in his figure of the axolotl. I have found it present in *A. tigrinum*, *A. opacum*, *A. jeffersonianum*, and *A. microstomum*. In *A. opacum* and *A. tigrinum* it is present in an early stage. It seems to me that the septomaxilla will be found to be a constant feature of the genus *Ambystoma*.

In conclusion, it is important to emphasize that the skull of salamanders, being largely cartilaginous, cannot be studied with complete success by the ordinary methods of dissection. Clearing the skulls *in toto* and using differential stains are not only advantageous but often necessary. Conclusions based on material studied by the older methods must be accepted with caution, for not only are sutures overlooked but often well-defined elements such as the septomaxilla are missed entirely. Then the thin bony elements are subject to fracture in life. "Jugals" which I have found in *Rhyacotriton* proved on further study to be fractured portions of the maxillæ. "The "jugals" figured by Parker (1877, Pl. xxvii, fig. 6) in *Ambystoma opacum* are of similar character. The

lacrymal figured by Cope (1889, Pl. xi, fig. 2) in *Amphiuma means* is apparently also a fractured splinter. Stains, such as alizarin, which bring out sutures will, I believe, solve the mystery of the various azygous cranial elements which have been reported in salamanders. The questions of homology indicated above cannot be determined until many more forms have been examined and studied with regard to their mutual relations. This work needs the support from the field of zoogeography as well as from that of comparative anatomy. Still, one conclusion may be certainly reached at this time from the above observations. The cranial elements even within the single order Caudata cannot be homologized at random. Contacts do not always determine homology. An understanding of relationships is essential.

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PLATE I

PLATE I

Dorsal surface of the cranium.

Fig. 1. *Eurycea leprosus*.

Fig. 2. *Ædipus adspersus*.

Fr.—frontal; *l.*—foramen of lacrymal duct; *Mx.*—maxilla; *Na.*—nasal; *Pa.*—palatine; *Per.*—periotic; *P.mx.*—premaxilla; *Pr. f.*—prefrontal; *Q.*—quadrate; *S.mx.*—septomaxilla; *Sq.*—squamosal; *Vo.*—prevomer.

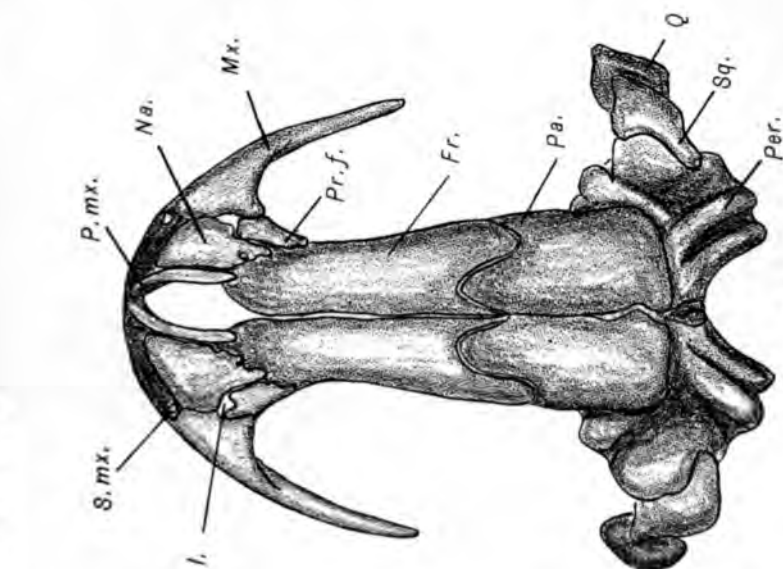


Fig. 1

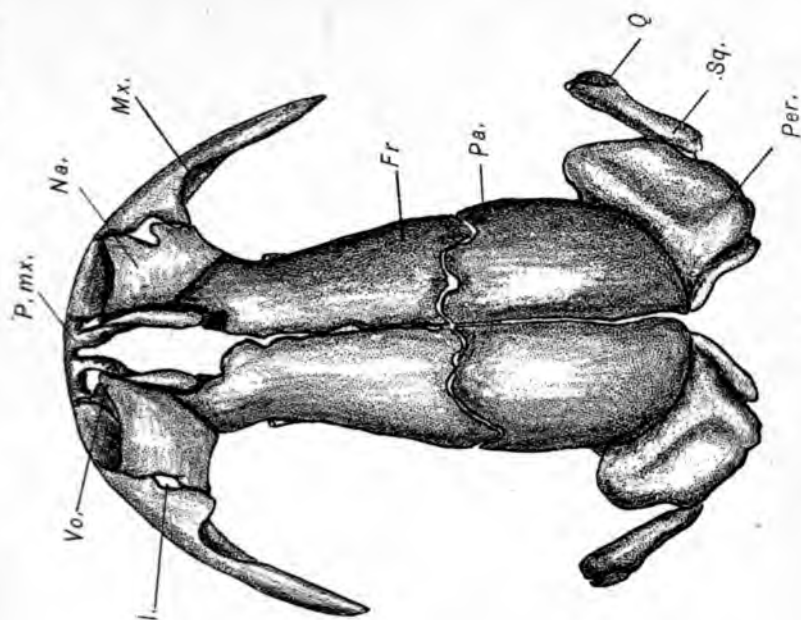


Fig. 2

PLATE II

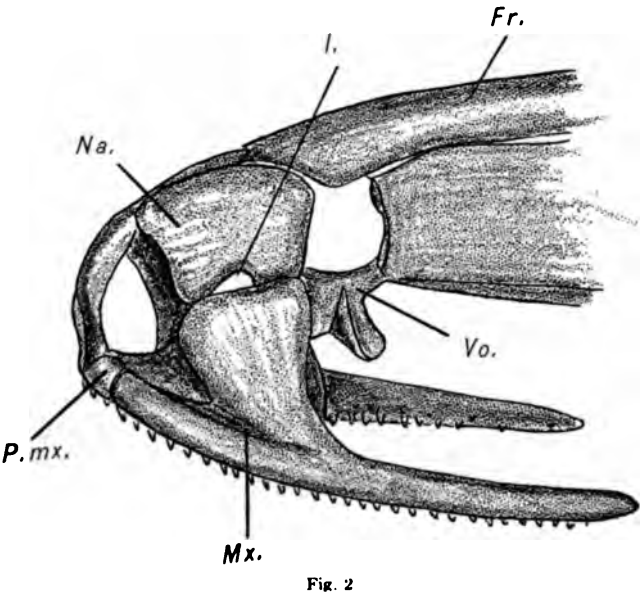
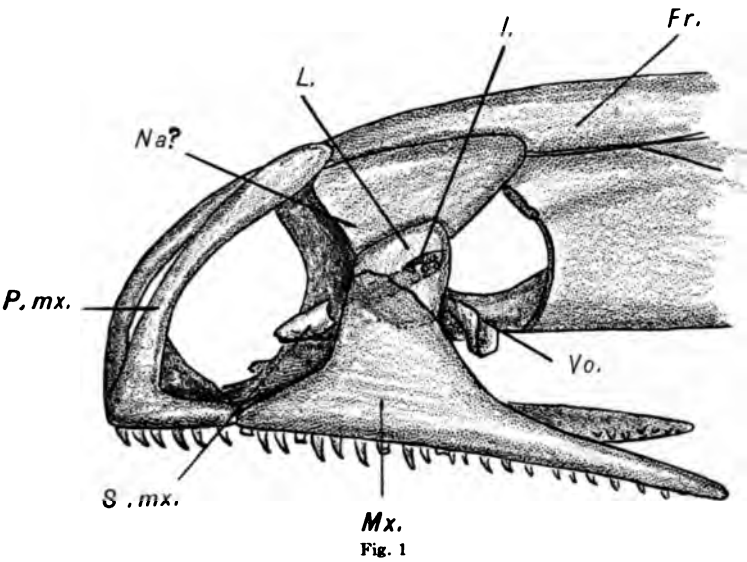
PLATE II

Lateral aspect of anterior portion of the cranium: cartilaginous elements omitted.

Fig. 1. *Rhyacotrilon olympicus*.

Fig. 2. *Ædipus adpersus*.

Fr.—frontal; *L.*—lacrymal bone; *l.*—foramen of lacrymal duct; *Mx.*—maxilla; *Na.*?—nasal?; *P.mx.*—premaxilla; *S.mx.*—septomaxilla; *Vo.*—prevomer.



Article II.—NOTES ON THE HERPETOLOGY OF SANTO DOMINGO

BY KARL PATTERSON SCHMIDT

The collections of The American Museum of Natural History have received important accessions from the Santo Domingan part of Hispaniola, which is herpetologically perhaps the least known of the West Indian islands. Mr. Clarence R. Halter made a collection for the Museum in the summer of 1915, chiefly from the Yuna Valley in the eastern part of the republic and consisting of four hundred and sixty-nine specimens. One hundred and forty-eight specimens from the arid area near Monte Cristi and the interior of the northern Yaqui Valley were collected by Mr. Axel Olsson and myself in the summer of 1916, in connection with the geological reconnaissance expedition from Cornell University. Mr. J. K. Noble presented to the Museum a small but interesting collection made while stationed at Macoris with the forces of the United States Marine Corps. A small collection made by R. H. Beck in the mountainous interior of the republic in 1917 was added to the Museum's collections by purchase. A small collection from the little-known province of Barahona was presented by Mr. John L. Phillips, in 1912. These Santo Domingan collections total six hundred and seventy-two specimens, representing thirty-four species. Two of these have previously been described as new (Schmidt, 1919, Bull. Amer. Mus. Nat. Hist., XLI, pp. 519-525) and an additional new species of *Leiocephalus* is described below.

Bufo gutturosus Latreille

Five specimens in the collection from Cercado de Mao, the Rio Amina, Monte Cristi, and Barahona. Juvenile specimens, apparently recently transformed, were collected at Cercado de Mao, May 20 and at Monte Cristi, June 10, 1916. The measurements of the largest specimen (A. M. N. H. No. 5919, Barahona) are as follows:

Snout to vent	92 mm.
Snout to posterior border of tympanum	24 mm.
Greatest breadth of head	28 mm.
Length of forelimb from axilla	46 mm.
Length of hind limb from vent	94 mm.

To the differences pointed out by Stejneger (1904, Rept. U. S. Nat. Mus., 1902, p. 570) between *Bufo gutturosus* and *Bufo lemur* of Porto Rico, the wide divergence in proportions must be added, the Hispaniolan species being much shorter limbed and probably larger.

***Hyla dominicensis* (Tschudi)**

Thirty-three specimens from Cercado de Mao, San Pedro de Macoris, Sanchez, and Cano Hondo (San Lorenzo) are referred to this species. The specimen from Cercado de Mao is a tadpole nearly ready to transform, measuring 45 mm. from snout to tip of tail and 16 mm. from snout to vent, and was collected May 20, 1916.

***Hyla pulchrilineata* Cope**

Forty-two specimens from Sanchez and Cano Hondo (San Lorenzo). This species was breeding in swamps near Sanchez during the latter half of May 1915. The eggs are deposited directly in the water and there is apparently no abbreviation of the larval stage, thus forming an exception to the general rule among tropical *Hylas*. As in the preceding species, the males are provided with a horny patch on the outer face of the first joint of the thumb. The light stripes, which are white in alcohol, are golden yellow in life.



Fig. 1. *Hyla pulchrilineata* Cope. A. M. N. H. No. 3247, natural size.

***Eleutherodactylus weinlandi* Barbour**

Six specimens from Cano Hondo (San Lorenzo), June 24, 1915. These specimens were collected beneath stones on a dry, sunny hillside. The measurements of the largest (A. M. N. H. No. 3299) are as follows:

Snout to vent	38 mm.
Snout to posterior border of tympanum	13 mm.
Greatest breadth of head	13 mm.
Forelimb from axilla	22 mm.
Hind limb from vent	55 mm.



Fig. 2. *Eleutherodactylus weinlandi* Barbour. A. M. N. H. No. 3296, natural size.

***Eleutherodactylus inoptatus* (Barbour)**

A single specimen, apparently the second to be recorded, from Villa Rivas, June 19, 1915. The type locality is Diquini, Haiti, at the opposite end of the island. Measurements as follows:

Snout to vent	54 mm.
Snout to posterior border of tympanum	21 mm.
Greatest breadth of head	23 mm.
Forelimb from axilla	36 mm.
Hind limb from vent	103 mm.

***Eleutherodactylus montanus* Schmidt**

This species appears to be confined to the mountains of the Cibao. It does not appear to be closely related to any other Hispaniolan species but may be derived from *E. auriculatus*, to which it is related in the disposition of its vomerine teeth.



Fig. 3. *Eleutherodactylus montanus* Schmidt. Type, A. M. N. H. No. 6435, twice natural size.

Five additional juvenile specimens of *Eleutherodactylus* probably represent another mountain species of this genus. It seems preferable to postpone its description for further and better material.

***Sphaerodactylus difficilis* Barbour**

Thirty-one specimens of this highly variable species from Cereado de Mao, Los Quemados, San Pedro de Macoris, Sanchez, and Cano

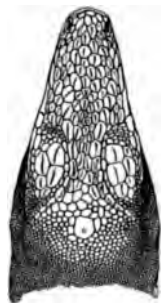
Hondo (San Lorenzo). I found this little gecko chiefly under the loose bark of such trees as the "almacigo" in the western part of the island. At Sanchez it was the commonest house gecko.

This species appears to be fully as variable as *S. macrolepis*, which ranges from the Virgin Islands to Mona Island, and parallels it in color variation. Barbour (1914, Mem. Mus. Comp. Zool., XLIV, p. 265) in describing the species calls attention to the variation in size of dorsal scales. In the present series the number of scales around the body ranges from 42 to 64. The spectacle mark on the shoulder is present in only two specimens.

***Anolis ricordii* Duméril and Bibron**

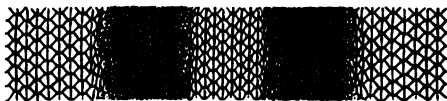
Four specimens from Sanchez and Villa Rivas, shot in trees.

In addition to the characters pointed out by Stejneger (1904, Rept. U. S. Nat. Mus., 1902, p. 629) as distinguishing this species from the Porto Rican *Anolis cuvieri*, the difference in coloration may be mentioned. The Porto Rican species is usually a vivid green in life, changing to a mottled phase, gray, green, and black, and to a dark bluish black. The Hispaniolan species appears to be usually green with dark-edged transverse bands of light greenish yellow.



4

Fig. 4. *Anolis semilineatus* Cope. A. M. N. H. No. 6262, four times natural size.



5

Fig. 5. *Anolis semilineatus* Cope. Scales around the middle of the body. A. M. N. H. No. 6262, four times natural size.

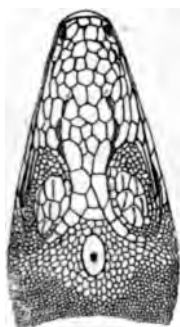
***Anolis semilineatus* Cope**

Five specimens from Samana, Sanchez, and Villa Rivas. It was found on low weeds. This species represents the slender-bodied group of *Anolis* with heterogeneous dorsal scales in Hispaniola. It is widely distinct from the Porto Rican representatives of the same group.

Anolis olssoni Schmidt

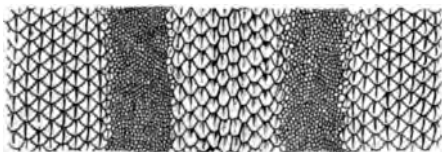
Two specimens from Monte Cristi.

This species replaces *Anolis semilineatus* in the arid parts of the northern valley. The first specimen taken by the writer was ruined on the horse-back journey into the interior, and careful search on our return to Monte Cristi resulted in the discovery of only one more specimen, on the last day of our stay.



6

Fig. 6. *Anolis olssoni* Schmidt. Type, A. M. N. H. No. 13400, four times natural size.



7

Fig. 7. *Anolis olssoni* Schmidt. Scales around the middle of the body. A. M. N. H. No. 13400, four times natural size.

It lives in the bunches of tall grass which form the chief vegetation on the dry hillsides of the Monte Cristi area. About half of the grass stems are dry and white, and the gray and white coloration of this species with its longitudinal lines makes an extremely effective protective resemblance. This resemblance is turned to the best account by the lizard, for when frightened it assumes a rigid posture, with the tail hanging straight down, and seems literally to disappear before one's eyes among the grayish green and white stems of grass.

Anolis chlorocyanus Cope

Seventy-five specimens of this brilliant green species in the collection from Puerto Plata, Samana, Sanchez, Villa Rivas, Cano Hondo, San Pedro de Macoris, Caimito on the Rio Cana, and Los Quemados on the Rio Gurabo. Mr. Olsson and I did not observe this species near Monte Cristi, and it probably does not inhabit the more arid parts of the island. The numbers of specimens secured in the Samana-Sanchez region indicate that it is very abundant, while in the western part of its range

(between Cano and Gurabo Rivers, affluents of the Yaqui), it was a rare species. We saw it on thatched roofs of native huts.

The most usual coloration is bright green with more or less black on the head. The range of color change is wide, a bluish green phase and one variously marked with black being the most common. The throat-fan is brownish black.

In the characters of its head shields, especially in the slight development of the supra-orbital semicircles, *A. chlorocyanus* appears to be allied to *A. iodurus* of Jamaica, perhaps more closely than to any other Hispaniolan or Cuban species, and it is certainly widely distinct from the green *Anolis evermanni* of Porto Rico.

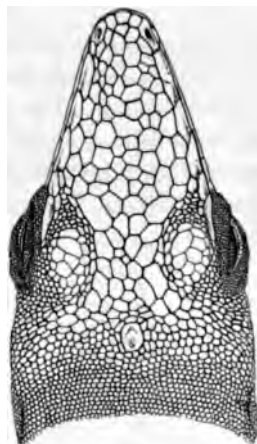


Fig. 8. *Anolis chlorocyanus* Cope. A. M. N. H. No. 13642, three times natural size.

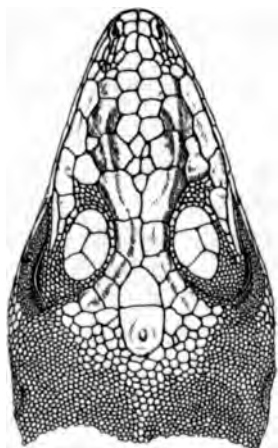


Fig. 9. *Anolis distichus* Cope. A. M. N. H. No. 7562, four times natural size.

***Anolis distichus* Cope**

Eighty-one specimens from Monte Cristi, Puerto Plata, Samana, Sanchez, Villa Rivas, Cano Hondo (San Lorenzo), San Pedro de Macoris, Azua Province, and Barahona.

This species is readily recognized by the large occipital shield, with usually a single large "preoccipital" between it and the supra-orbital semicircles. The coloration is extremely variable, green variously mottled or vermiculated with black being the most common phase. The throat-fan is bright orange.

***Anolis cybotes* Cope**

One hundred and fifty-seven specimens of this species represent the localities Monte Cristi, Puerto Plata, Sanchez, Samana, Villa Rivas, Cano Hondo (San Lorenzo), San Pedro de Macoris, and the interior of Azua Province.

The presence of numerous specimens of this species with more or less well-defined keels on the ventral scales indicates that *A. haetianus* Garman is probably a synonym of *A. cybotes*.

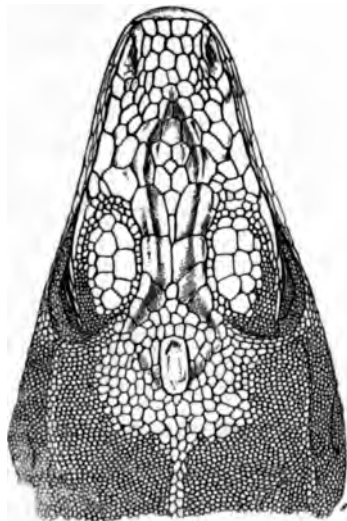


Fig. 10. *Anolis cybotes* Cope. A. M. N. H. No. 8586, three times natural size.

A. cybotes is evidently the most abundant *Anolis*, possibly the most abundant lizard, in Santo Domingo, equally represented in the arid and humid areas and extending high into the mountains. In this respect and in coloration and color change, it resembles *Anolis cristatellus* of Porto Rico, from which it is distinguished chiefly by the absence of a tail-fin.

***Anolis citrinellus* Cope**

A single specimen from Samana is referable to this species. The supraorbital semicircles are considerably in contact, enclosing a small scale, but the specimen in other respects accords with the description of *citrinellus*.

Key to the Species of *Anolis* in Santo Domingo

1. Dorsal scales entirely or in part surrounded by granules; tail of male with high fin-like crest. *A. ricordii*.
Dorsal scales granular or enlarged, not as above; tail without "fin" 2.
2. Dorsal scales large, flat, keeled, imbricate, ventrals strongly keeled, laterals small, granular; tail very long. 3.
Dorsal scales small, granular, smooth or feebly keeled. 4.

3. Supraorbital semicircles separated by two rows of scales.....*A. semilineatus*.
Supraorbital semicircles in contact or separated by a single row of scales.
A. olssoni.
4. Dorsal scales not or only very slightly enlarged on vertebral line; occipital
separated from supraorbital semicircles by a single scale nearly as large as
the occipital.....*A. distichus*.
Dorsal scales enlarged, often feebly keeled on vertebral line; no large pre-occipital
scale.....5.
5. Scales of supraorbital semicircles not much enlarged, widely separated.
A. chlorocyanus.
Supraorbital semicircles in contact or narrowly separated.....6.
6. A dorsonuchal fold.....*A. cybotes*.
No dorsonuchal fold.....*A. citrinellus*.

(I have omitted *Anolis pulchellus*, *A. cristatellus*, and *A. stratulus* from the Santo Domingan Anoles as probably erroneously recorded.)

***Leiocephalus schreibersii* (Gravenhorst)**

Mr. Olsson and I collected twenty-five specimens of this species at Monte Cristi, where it is the most abundant species on the sandy beach.

The larger and more brilliantly colored males are found only along the beach, while the females and young are found on the arid hillsides farther back, as well as on the beach. The females are characterized by the presence of a black spot on each side just above the axilla.

***Leiocephalus personatus* Cope**

The collection contains fifty-nine specimens from Monte Cristi, Puerto Plata, and Sanchez, and I observed it also at Sabaneta in the interior.

As in the preceding species, the adult males are much more brightly colored than the juvenile and female specimens. In the largest males the back is gray and the sides are bright red and green, the red predominating; the belly is light green, the upper surface of the hind legs bright green. The vivid black spots of the throat and the lateral light stripes of the young disappear almost entirely in the largest specimens.



Fig. 11. *Leiocephalus personatus* Cope. A. M. N. H. No. 16155, three times natural size.

***Leiocephalus barahonensis*, new species**

Diagnostic Characters.—Parietals and transverse supraoculars distinct. Scales behind ear keeled and imbricate, not granular; three scales between the rostral and the first supraorbital; frontal and prefrontal scales entirely smooth, separated from the canthal scales by an elongate narrow scale; forty scales around the body; dorsal and caudal crests low. No dorsolateral light line in the adult; throat heavily spotted or vermiculated with brown in both young and adult.

Range.—Southeastern Santo Domingo, Barahona Province.

Type.—A. M. N. H. No. 2736; Barahona, Santo Domingo; J. L. Phillips; 1912.

Description of Type.—

Head scales well developed; three scales between the rostral and the first supraocular; a pair of frontals, a pair of prefrontals, and a pair of supranasals; each of these scales in contact with its fellow, but enclosing a series of three small median scales; frontals and prefrontals separated from the canthal scales by an elongate rhomboidal scale; three pairs of supraorbitals; seven supraoculars on each side; a small occipital, bordered by a pair of narrow parietals, followed on each side by a broad parietal twice as broad as the inner; anterior head shields smooth, supraoculars and parietals striate; five upper and five lower labials. Dorsal and lateral scales sharply keeled, slightly mucronate; ventral scales smooth; about forty scales around the middle of the body; scales of the sides of the neck like the dorsals; dorsal and caudal crests low.

Back greenish gray, nearly uniform; sides darker; venter lighter greenish gray, throat and chin heavily spotted with dark brown.

Notes on Paratypes.—The two paratypes agree in essential characters with the type. The smaller specimen has a faint dorsolateral line anteriorly. Both have only two scales in the median series, between the frontals and prefrontals.

This species is a very distinct one, allied to *L. personatus*, from which it is immediately distinguished by the smooth frontal and prefrontal shields and the much lower crests of the back and tail. *L. semilineatus* Dunn, recently described from Thomazeau, Haiti, appears to be more closely allied to *L. melanochlorus* than to *personatus*, if the number of shields between the rostral and supraorbitals may be relied upon as a group character. I have used a somewhat different terminology for the head-shields than that of Dunn (1920, Proc. New England Zool. Club, VII, pp. 33-34), his "preocular" and "loreal" corresponding to the two scales I refer to as canthals.

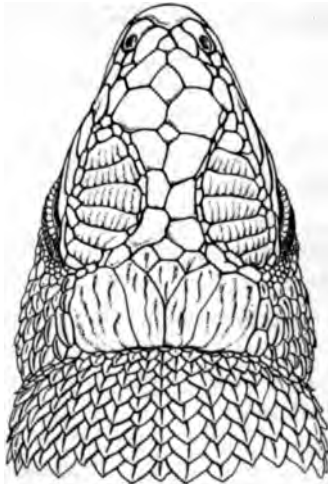


Fig. 12. *Leiocephalus barahonensis* Schmidt. Type, A. M. N. H. No. 2736, three times natural size.

Key to the Species of *Leiocephalus* in Santo Domingo and Haiti

1. Sides of neck behind ear covered with small sharp granular scales . . . *L. schreibersii*.
Sides of neck covered with keeled imbricated scales, like dorsals 2.
2. Four scales between rostral and first supraorbital 3.
Three scales between rostral and first supraorbital 4.
3. A long narrow scale between the large canthal and the frontal and prefrontal
scales on each side *L. melanochlorus*.
Frontal and prefrontals in contact with canthals *L. semilineatus*.
4. Frontals and prefrontals strongly keeled *L. personatus*.
Frontals and prefrontals smooth *L. barahonensis*.

***Celestus (Celestus) costatus* (Cope)**

Twenty-two specimens in the collection from Samana, Sanchez, Villa Rivas, and the interior of Azua Province.

Mr. Halter's field notes show that this species is distinctly arboreal. All but one of his specimens were shot on cocoanut palms or on stumps.

It is interesting that the native name for this species is "Lucia," applied in Porto Rico to the *Mabuya*. It is probably used for both the *Mabuya* and the *Celestus* in Santo Domingo.

***Celestus (Sauresia) sepsoides* Gray**

One specimen of this interesting species was collected by Mr. Halter at Sanchez, and a second comes from San Pedro de Macoris, collected by Mr. J. K. Noble.

Mr. Halter's field notes report that his specimen was dug out of the ground about six inches below the surface. The limbs are not used in progression, which is snake-like.

This is one of the forms for which the use of a subgeneric name is most useful. *Sauresia* represents a distinct section of the West Indian *Celestus*, but to give it the rank of a full genus would disguise its obvious relations.

***Ameiva chrysolaema* Cope**

Mr. Olsson and I collected nineteen specimens of this species in the western part of Santo Domingo at the mouth of the Cana River and at Monte Cristi. Another specimen comes from Barahona in the south-western part of the republic. These are the first records, apparently, outside of Haitian territory. Its absence in collections from the eastern

end of the island is presumptive evidence that *A. chrysolaema* is confined to the more arid sections.

This species is extremely abundant on the river bottoms in western Santo Domingo. It was observed feeding on angleworms, grasshoppers, and scorpions.

Ameiva vittipunctata Cope

A single specimen from Los Quemados on the Gurabo River is referable to this species.

Ameiva tæniura Cope

Twelve specimens in the collection from the Gurabo River, the Cana River, San Pedro de Macoris, the interior of Azua Province, Sanchez, Samana, Villa Rivas, and Puerto Plata.

This species belongs distinctively to the more humid habitat conditions in Santo Domingo. Mr. Olsson and I found it only in shaded and moist localities as far west as the Cana River. In the territory visited by us it was very rare, while at Samana and Sanchez it appears to be the common *Ameiva* of the beach.

It is unfortunate that Barbour and Noble (1915, Bull. Mus. Comp. Zool., LIX, p. 435) confused this species with *Ameiva lineolata*, which belongs to a very distinct section of the genus. The present collection contains juvenile specimens of *A. tæniura*, much smaller than adult *A. lineolata*, with which there is no approach in coloration.

Ameiva lineolata Duméril and Bibron

Eleven specimens of this interesting and distinct form were collected at Monte Cristi by Mr. Olsson and myself. It was absent on the beaches and low ground, inhabiting the dry hills immediately back of the town, as well as the slopes of the Moro or Grange Mountain.

Like *A. wetmorei* in Porto Rico, with which it is allied, this species is doubtless confined to the more arid districts of the island.

Key to the Species of *Ameiva* in Santo Domingo

1. Caudal scales smooth, oblique..... *A. lineolata*.
Caudal scales keeled, straight..... 2.
2. Back uniform in color or nearly so between dorsolateral light bands... *A. tæniura*.
Back with light lines or spots..... 3.
3. Three supraoculars; frontonasal with an anterior angle..... *A. vittipunctata*.
Four supraoculars; frontonasal truncate or rounded anteriorly... *A. chrysolaema*.

***Amphisbæna manni* Barbour**

Four specimens from Sanchez, San Pedro de Macoris, and the province of Santo Domingo.

These specimens show little variation. The body-rings range from 222 to 228, the tail-rings from 21 to 24. Two have six preanal pores and two have eight.

***Typhlops lumbricalis* (Linné)**

One specimen from San Pedro de Macoris, collected by Mr. J. K. Noble.

I have elsewhere endeavored to show (1920, Ann. N. Y. Acad. Sci., XXVIII, p. 195) that the Porto Rican *Typhlops* usually referred to *T. lumbricalis* is in reality so well distinguishable from the *Typhlops* of Cuba as to warrant its recognition as a separate species. The single specimen at hand from Hispaniola is insufficient material on which to base a conclusion as to its distinctness. The specimen has, however, only 245 scales from snout to vent, while in the Cuban series examined by me the minimum is 270. The status of the Hispaniolan, Cuban, and Jamaican *Typhlops lumbricalis* offers an interesting problem for investigation.

***Typhlops pusillus* Barbour**

One specimen of this species was collected by me at Caimito, on the Cana River, and a second comes from Sanchez, collected by C. R. Halter.

***Epicrates striatus* Fischer**

Three specimens: one from Los Quemados, one without further data than eastern Santo Domingo, and one from San Lorenzo.

The scale counts of these three specimens follow:

A. M. N. H. No.	Sex	Dorsal Scales	Ventrals	Subcaudals
9038	♀	41-55-27	292	65
6374	♀	39-55-27	289	48
16079	♀	43-53-31	285	73

The unusually low number of subcaudals in No. 6374 may be due to injury of the tail.

The specimen brought to us at Los Quemados by a boy measured two meters in length. It was about as thick as a man's wrist, due chiefly to the distention of the body by twenty-six eggs, measuring from 30 to 40 mm. by 25 mm.

Tropidophis maculata (Bibron)

A single specimen collected at Sanchez by C. R. Halter. The ventral plates number 181, the subcaudals 39, the dorsal rows 25-27-19.

This specimen was captured in a swamp with one *Hyla pulchrilineata* in its mouth while it was engaged in constricting another one. As numerous mated pairs of *Hyla pulchrilineata* were found at the same time, it is presumable that the snake attacked a pair in embrace.

Hypsirhynchus ferox Günther

One specimen from Los Quemados; another from Cercado de Mao. The one from Cercado was found coiled on the river-bank among loose rocks.

Uromacer catesbyi (Schlegel)

There are twenty-two specimens of this species in the collection, representing the following localities: Barahona, San Pedro de Macoris, San Lorenzo, Sanchez, Villa Rivas, the interior of Azua Province, Los Quemados, and Cercado de Mao.

Uromacer frenatus (Günther)

A single specimen from Los Quemados, collected by the writer.

This specimen is of interest in having only 171 ventral plates and 177 subcaudals; dorsal scales normal, 17-17-11. Boulenger gives ventrals 182-193 and subcaudals 201-205. Dunn (1920, Proc. New England Zool. Club, VII, p. 44) describes a specimen with 171 ventral plates and 194 subcaudals from Tortuga Island. It seems best to consider both these specimens as somewhat aberrant *U. frenatus*.

Uromacer oxyrhynchus Duméril and Bibron

Four specimens of this species from Sanchez and Samana. A specimen too badly injured for preservation was brought to our camp at Los Quemados, on the Gurabo River. This specimen was the largest I have seen, measuring nearly two meters.

Leimadophis parvifrons protenus (Jan)

I follow Dunn (*loc. cit.*, p. 38) in the use of this name for the majority of *Leimadophis* from Santo Domingo. There are thirteen specimens in the collection from Barahona, Azua Province, San Pedro de Macoris, and Los Quemados. One of the two specimens from Barahona is

colored exactly like the typical form from the southwestern peninsula but agrees with *protenus* in the higher ventral count. The juvenile specimen from Barahona is very light in color, the longitudinal striping being only distinguishable anteriorly. On the first sixth of the body, the first three scale-rows are colored like the venter; the fourth and half of the fifth is occupied by a black band continued through the eye to the snout; the upper half of the fifth row to the middle of the eighth row is light, and the three median scale-rows plus the borders of the eighth row are dark. This I regard as a juvenile coloration, which throws light on the shift in the position of the dorsolateral light stripe in *L. alleni* and *L. tortuganus* (Dunn, *loc. cit.*, p. 40).

***Leimadophis parvifrons niger* Dunn**

Two specimens collected by Mr. Halter at Sanchez agree exactly with Dunn's description in color (*loc. cit.*, p. 39). The ventral plates number 151 in both; the subcaudals 122 and 123.

***Pseudemys palustris* (Gmelin)**

Nine specimens of this species were taken in the Yuna River by Mr. Halter. At Monte Cristi this turtle was a staple article of food. The Monte Cristi specimens were much larger than any of the Porto Rican specimens I have seen.

Article III.—A LIST OF TURK ISLANDS FISHES, WITH A DESCRIPTION OF A NEW FLATFISH

BY JOHN TREADWELL NICHOLS

PLATE III

In September 1919, The American Museum of Natural History received as a gift from Mr. Louis L. Mowbray, now of the Aquarium at Miami, Florida, a considerable number of marine fishes collected by him from Turk Islands in the Bahamas during June and July 1916. One of these (a very interesting, small flatfish) is here described as new. The fishes of this interesting locality, reputed to be one of the richest in that general region for marine forms, seem not to have been previously reported on. A list of the species contained in the collection, therefore, is appended. To this list are added also other species recorded by Mr. Mowbray at Turk Islands during the same dates, such being designated by an asterisk. It will form a basis for a more thorough survey of the islands' fishes, we trust at an early date. The nomenclature of Jordan and Evermann's 'Fishes of North and Middle America' has been followed in the list.

PLATOTICHTHYS, new genus

Preopercular margin about as in *Achirus*. Eyes small, close together, mouth very small, approximately symmetrical. Minute conical teeth present. Ventral fins symmetrical, the anal commencing between their posterior base. Body deep and excessively compressed, the caudal sessile but disconnected from dorsal and anal. Body dextral; lateral line with a short, abrupt arch, the chord of same 1.8 in head. Small pectoral fin present on both sides. Gill-openings wide, confluent below.

Type *P. charles*, new species. (*Platol[t]ichthys*—a very flat fish.)

Platotichthys charles, new species

The type, No. 7388, American Museum of Natural History, is our only specimen and was taken at Turk Islands, Bahamas, June-July 1916, by L. L. Mowbray. It is 33 mm. long to base of caudal. Depth, 1.5 in this measure; head, 4.0; lower eye in head, 6.0; lower eye to tip of snout, 3.2; interorbital, 4.0; maxillary, 4.0; depth of peduncle, 2.3; pectoral, 2.7; ventral, 1.6; longest dorsal and anal rays, 2.0. Thickness about equal to diameter of eye. Caudal about 1.6 (tip broken). Dorsal commences on the profile, in front of the upper eye. Body broadly, very regularly oval, anterior profile vertical, lower jaw slightly projecting. Dorsal about 95. Anal about 73. No evident scales. Colored side pale, probably sand-grey in life, marked with round dark specks of varying size, the largest half the diameter of eye. (*Charles*—compressed like paper.)

LIST OF FISHES FROM TURK ISLANDS

- | | |
|--|---|
| *1. <i>Ginglymostoma cirratum</i> . | *34. <i>Sphyræna picudilla</i> . |
| *2. <i>Carcharhinus limbatus</i> . | 35. <i>Myripristis jacobus</i> (a number of specimens). |
| *3. <i>Sphyrna tiburo</i> . | *36. <i>Holocentrus ascensionis</i> . |
| *4. <i>Sphyrna zyggæna</i> . | 37. <i>Holocentrus coruscus</i> . |
| *5. <i>Dasyatis say</i> . | 38. <i>Flammeo marianus</i> . |
| *6. <i>Aëtobatus narinari</i> . | 39. <i>Upeneus maculatus</i> . |
| 7. <i>Anguilla chrysypa</i> . | 40. <i>Upeneus martinicus</i> . |
| 8. <i>Leptocephalus conger</i> . | *41. <i>Auxis thazard</i> . |
| 9. <i>Myrichthys ocellatus</i> . | *42. <i>Scomberomorus maculatus</i> . |
| *10. <i>Lycodontis moringa</i> . | *43. <i>Scomberomorus regalis</i> . |
| *11. <i>Lycodontis funebris</i> . | *44. <i>Seriola zonata</i> . |
| 12. <i>Echidna catenata</i> . | *45. <i>Seriola lalandi</i> . |
| *13. <i>Tarpon atlanticus</i> . | *46. <i>Decapterus punctatus</i> . |
| *14. <i>Elops saurus</i> (common). | 47. <i>Trachurops crumenophthalmus</i> . |
| *15. <i>Albula vulpes</i> . | 48. <i>Caranx ruber</i> . |
| 16. <i>Sardinella sardina</i> (a number of specimens). | *49. <i>Caranx bartholomæi</i> . |
| *17. <i>Opisthonema oglinum</i> . | *50. <i>Caranx hippos</i> . |
| 18. <i>Stolephorus brownii</i> . | *51. <i>Caranx crysos</i> (most common <i>Caranx</i>). |
| 19. <i>Synodus synodus</i> . | *52. <i>Caranx latus</i> . |
| 20. <i>Cyprinodon variegatus</i> . | *53. <i>Trachinotus glaucus</i> . |
| 21. <i>Tylosurus notatus</i> . | 54. <i>Trachinotus falcatus</i> . |
| 22. <i>Tylosurus acus</i> . | 55. <i>Apogonichthys stellatus</i> . |
| *23. <i>Hyporhamphus unifasciatus</i> . | 56. <i>Petrometopon cruentatus</i> . |
| *24. <i>Hemiramphus brasiliensis</i> . | *57. <i>Bodianus fulvus fulvus</i> . |
| 25. <i>Halocypselus evolans</i> . | *58. <i>Bodianus fulvus ruber</i> . |
| 26. <i>Aulostomus maculatus</i> . | *59. <i>Bodianus fulvus punctatus</i> . |
| *27. <i>Siphostoma jonesi</i> . | *60. <i>Epinephelus adscensionis</i> . |
| *28. <i>Corythoichthys cayorum</i> . | *61. <i>Epinephelus striatus</i> . |
| *29. <i>Hippocampus punctulatus</i> . | *62. <i>Epinephelus guttatus</i> . |
| 30. <i>Atherina laticeps</i> ¹ (a number of specimens). | *63. <i>Epinephelus morio</i> . |
| 31. <i>Atherina stipes</i> . | *64. <i>Promicrops itaiara</i> . |
| 32. <i>Mugil curema</i> . | *65. <i>Mycteroperca venenosa</i> . |
| 33. <i>Sphyræna barracuda</i> (very common). | *66. <i>Mycteroperca bonaci</i> . |

¹Very likely *laticeps* is merely an individual variant of *stipes*.

- *67. *Mycteroperca falcata*. Nat. Hist., XXXI, p.
 *68. *Mycteroperca tigris*. 190).
 69. *Hypoplectrus unicolor*. 102. *Kyphosus sectatrix*.
 *70. *Diplectrum formosum*. 103. *Eques acuminatus*.
 71. *Paranthias furcifer*. 104. *Eques punctatus*.
 *72. *Rypticus saponaceus*. 105. *Chromis multilineatus*.
 73. *Priacanthus cruentatus*. 106. *Eupomacentrus fuscus*.
 *74. *Neomænis griseus*. 107. *Eupomacentrus analis*.
 *75. *Neomænis jocu*. 108. *Eupomacentrus leucostictus*.
 *76. *Neomænis apodus*. 109. *Eupomacentrus partitus*.
 77. *Neomænis bucanella*. 110. *Abudefduf saxatilis*.
 78. *Neomænis rivianus*. 111. *Microspathodon chrysurus*.
 *79. *Neomænis aya*. *112. *Lachnolaimus maximus*.
 *80. *Neomænis analis*. *113. *Harpe rufa*.
 *81. *Neomænis synagris*. *114. *Iridio radiatus*.
 82. *Neomænis mahogoni*. 115. *Iridio garnoti*.
 *83. *Neomænis hastingi* (Bean, *116. *Iridio bivittatus*.
 1898, Bull. Amer. Mus. 117. *Thalassoma nitidum*.¹
 Nat. Hist., X, p. 45). 118. *Thalassoma bifasciatum*.
 *84. *Ocyurus chrysurus*. 119. *Sparisoma hoplomystax*.
 85. *Rhomboplites aurorubens*. 120. *Sparisoma aurofrenatum*.
 86. *Apsilus dentatus*. *121. *Sparisoma abildgaardi*.
 *87. *Hæmulon album*. *122. *Sparisoma chrysopterum*.
 *88. *Hæmulon parra*. *123. *Sparisoma viride*.
 *89. *Hæmulon sciurus*. *124. *Sparisoma flavescens*.
 *90. *Hæmulon plumieri*. *125. *Scarus vetula*.
 *91. *Hæmulon flavolineatum*. *126. *Scarus croicensis*.
 92. *Brachygenys chrysargyreus*. *127. *Scarus cæruleus*.
 *93. *Bathystoma striatum*. *128. *Pseudoscarus guacamaia*.
 *94. *Anisotremus surinamensis*. 129. *Pseudoscarus plumbeus*
 (Bean, 1912, Proc. Biol.
 *95. *Calamus calamus*. Soc. Wash., XXV, p.
 96. *Calamus bajonado*. 125).
 *97. *Calamus arcifrons*. *130. *Chætodipterus faber*.
 98. *Eucinostomus harengulus*. *131. *Chætodon ocellatus*.
 99. *Uæma lefroyi*. 132. *Chætodon striatus*.
 100. *Xystæma cinereum*. *133. *Chætodon capistratus*.
 101. *Xystæma harana* (Nichols, 134. *Pomacanthus arcuatus*.
 1912, Bull. Amer. Mus.

¹The opinion has been advanced that *nitidum* is the young of *bifasciatum*, but this has never been established to the writer's satisfaction.

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| 135. <i>Pomacanthus paru</i> . | *150. <i>Lactophrys bicaudalis</i> . |
| 136. <i>Holacanthus tricolor</i> (common). | *151. <i>Lactophrys trigonus</i> . |
| *137. <i>Angelichthys ciliaris</i> . | *152. <i>Lactophrys tricornis</i> . |
| *138. <i>Teuthis cæruleus</i> . | *153. <i>Spheroides spengleri</i> . |
| *139. <i>Teuthis hepatus</i> . | 154. <i>Canthigaster rostratus</i> . |
| 140. <i>Teuthis bahianus</i> . | *155. <i>Diodon hystrix</i> . |
| *141. <i>Teuthis helioides</i> (Barbour, 1905, Bull. Mus. Comp. Zool., XLVI, p. 127). | 156. <i>Chilomycterus spinosus</i> . |
| *142. <i>Balistes carolinensis</i> . | *157. <i>Scorpæna plumieri</i> . |
| *143. <i>Balistes vetula</i> . | *158. <i>Cephalacanthus volitans</i> . |
| 144. <i>Melichthys piceus</i> . | 159. <i>Gobius soporator</i> (a number of specimens). |
| 145. <i>Monacanthus ciliatus</i> . | 160. <i>Malacanthus plumieri</i> . |
| *146. <i>Monacanthus hispidus</i> . | 161. <i>Dactyloscopus tridigitatus</i> (a number of specimens). |
| 147. <i>Pseudomonacanthus amphioxys</i> . ¹ | 162. <i>Labrisomus nuchipinnis</i> . |
| *148. <i>Ceratacanthus scriptus</i> . | 163. <i>Labrisomus bucciferus</i> . |
| *149. <i>Lactophrys triqueter</i> . | 164. <i>Platophrys lunatus</i> . |
| | 165. <i>Platotichthys chartes</i> . |
| | *166. <i>Ogcocephalus radiatus</i> . |

¹The opinion has been advanced that this is the young of *Cantherines pullus*, but this has never been established to the writer's satisfaction.



Platystrophia chalybeata, Type — 3.3 mm. to base, caudal

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**Article IV.—DESCRIPTION OF A SKULL OF THE EXTINCT
MADAGASCAR CROCODILE, *CROCODILUS ROBUSTUS*
VAILLANT AND GRANDIDIER¹**

BY CHARLES C. MOOK

With Prefatory Note by W. D. Matthew

PLATE IV

PREFATORY NOTE

With the following article Dr. Mook begins a series of contributions to the osteology, affinities, and distribution of the Crocodilia, based primarily upon the study of the collections of fossil and Recent crocodiles in The American Museum of Natural History. Through the courtesy of the United States National Museum and the good offices of Mr. C. W. Gilmore, the entire collection of extinct crocodiles of that institution has been placed at his disposal for comparative study. We are no less indebted to Dr. Samuel Henshaw and Dr. Thomas Barbour, of the Museum of Comparative Zoology, for the loan of a series of skulls and skeletons of existing and extinct Crocodilia, including several species difficult to secure for comparison. Dr. A. G. Ruthven, of the University of Michigan has kindly loaned several skulls of South American crocodiles.

It is intended to publish the results of these researches in the form of a series of short contributions, dealing first with the later Tertiary and post-Tertiary species, then the early Tertiary forms, and afterwards the Mesozoic crocodiles, leading up to a general revision of the order.

W. D. MATTHEW.

In commencing this series of contributions upon the Crocodilia, the writer desires to express his acknowledgements to Professor Osborn and Doctor Matthew for the opportunity to study and describe the collections of fossil crocodiles in The American Museum of Natural History; to the American Museum Department of Herpetology; to Mr. C. W. Gilmore, of the United States National Museum; to Dr. Thomas Barbour, of the Museum of Comparative Zoology; and to Mr. A. G. Ruthven, of the University of Michigan, for the loan of specimens for comparison and for permission to publish the results in certain cases where it seemed advisable.

The following description, based upon a skull in the collection of the Museum of Comparative Zoology, is published by permission of the director of that Museum, Dr. Samuel Henshaw, and of Dr. Thomas Barbour.

¹Contributions to the Osteology, Affinities, and Distribution of the Crocodilia. No. 1.

The skull here described was collected by F. R. Wulsin near Antsirabe, Madagascar, and was figured by Dr. Barbour in 1918,¹ with notes on the validity of *C. robustus* as a species, the conclusion being that it is valid as a fossil species but does not exist at the present time, the large forms referred to it being very old individuals of *C. niloticus*. The geological horizon of the skull is unknown; it is probably late Pleistocene.

GENERAL FORM

The size of the specimen is small, but its proportions are stout. The breadth across the quadrato-jugal bones, across the cranial table, across the base of the snout, between the two canine grooves, and across the anterior part of the snout is in each case relatively great in proportion to the length of the skull. The premaxillary region is especially broad in proportion to its length; the length of these bones from the premaxillary-maxillary suture on the palate to the tip of the snout is only about two-thirds the maximum breadth across the premaxillaries.

The snout is exceedingly short, being only about one and one-sixth times as long as broad at the base. The posterior half of the external nares is bordered by a distinct ridge. A distinct ridge extends inward and backward from each canine groove to the nasal bone; from the nasal bone to the median line it becomes less distinct and finally disappears. Each of these ridges makes an angle of about 45° with the longitudinal axis of the skull. The superior portion of the premaxillo-maxillary suture roughly follows this ridge, but is slightly more transverse in direction. Posterior to each of these oblique ridges is a conspicuous depression; this depression lies over the fourth and fifth maxillary teeth. Posterior to these depressions is another pair of elevations extending obliquely inward and backward from the alveolar border; these elevations contain the roots of the fifth maxillary teeth. In front of each orbit a ridge extends anteriorly and externally from the superior border of the orbit, turning directly forward a short distance in front of the orbit; it dies out at the level of the seventh maxillary tooth. This ridge does not converge toward its opposite as in *C. porosus*, nor does it extend as far forward as in that species; the two ridges are also relatively farther apart than in *C. porosus*. The pitting is rough, relatively fine-textured on the ridges but coarser-textured between them. The two ridges are continued backward along the superior borders of the orbits, and along the external borders of the cranial table. The interorbital region is practically flat, or slightly concave; it is of moderate breadth. A prominent elevation is located between the anterior portions of the

¹Bull. Mus. Comp. Zool., LXI, No. 14.

orbits; it is situated entirely upon the anterior process of the frontal bone, and occupies most of this process.

The cranial table is concave laterally, and slopes conspicuously downward anteriorly. On the posterior border a pair of small processes extends backward, lying directly behind the supratemporal fenestræ. The table is very broad in proportion to its length; it is much narrower anteriorly than posteriorly, the lateral borders converging anteriorly. Each postero-external corner is elevated into a thick process which is very conspicuous.

The festooning of the jaw, seen laterally, consists of a straight maxillary border, a deep canine notch, a rapid descent from this to the level of the fourth and fifth maxillary teeth, then a slight rise to the level of the posterior end of the seventh maxillary tooth, a slight descent to the level of the tenth maxillary tooth, and finally a slight rise further back. From above is seen a relatively slight constriction at the canine notches, an expansion to the level of the fifth and sixth maxillary teeth, then a very slight constriction at the base of the seventh maxillary tooth. This posterior constriction differs from the corresponding constriction in most crocodile skulls in being situated nearer to the orbits than to the canine notch. The surface of the palate is concave in its anterior portion.

CAVITIES OF THE SKULL

EXTERNAL NARIAL OPENING.—This cavity is almost circular, but is slightly broader than long. The nasal bones project very slightly into the cavity itself.

ORBITS.—The orbits are large. They are almost as broad as long, and their anterior ends are bluntly pointed. They are situated near the middle of the skull, the antorbital region being little longer than the post-orbital.

SUPRATEMPORAL FENESTRÆ.—These fenestræ are of medium size and are irregularly oval in outline. They are relatively far apart; their longest axes approach each other at an angle of about 45°.

INFRATEMPORAL FENESTRÆ.—The infratemporal fenestræ are large; they contrast with those of most crocodiles in being at least two-thirds as long as the orbits. The sharp infratemporal processes of the quadratojugs are not present in the specimen, evidently having been broken off.

INFERIOR PREMAXILLARY FORAMEN.—The borders of this cavity are not preserved, but the cavity itself was evidently large.

PALATINE FENESTRÆ.—These cavities are relatively large, especially in the transverse direction. They extend as far forward as the center of the space between the seventh and eight maxillary teeth on the left side and the posterior part of the seventh tooth on the right side.

BONES OF THE SKULL

PREMAXILLARIES.—These bones are remarkable for their great breadth in proportion to their length, and the nearly uniform size and relatively uniform spacing of the teeth. The first, third, and fifth teeth are practically the same in size; the fourth is a little larger than these, and the second is a little smaller; the third and fourth are slightly farther apart than the others.

The premaxillo-maxillary suture on the palate is irregular, but is transverse in general direction. Its farthest posterior extension is only to the level of the center of the first maxillary tooth. On the superior surface, the suture extends as far back as the center of the space between the first and second maxillary teeth. The suture extends almost directly inward from each canine notch to a point near the nasal and then turns sharply backward. It crosses the ridge mentioned above. A pair of shallow pits is situated between the first and second premaxillary teeth, and internal to them, for the reception of the first mandibular teeth.

There is a similar pit between the third and fourth teeth, and a very shallow one between the fourth and fifth.

MAXILLARIES.—The maxillaries are very broad in proportion to their length. The sutures with the nasals are short; those with the lacrymals are more nearly antero-posterior in direction than transverse. The superior portions of the maxillo-jugal sutures are more nearly transverse in direction than antero-posterior. Nearer the inferior borders of the skull they curve backward, finally bending abruptly downward to the border in nearly vertical lines.

On the palate the maxillaries have twelve teeth on each side. The variation in the size and spacing of these is relatively slight. The maxillary teeth increase regularly in size from the first to the fifth. All of these are close together. The sixth is about the same size as the fourth and is close to the fifth. A shallow pit is situated between the sixth and seventh teeth, partly in line with the teeth themselves and partly internal to them. A larger pit is similarly situated between the seventh and eighth teeth. The seventh tooth is about equal in size to the eighth. The eighth, ninth, tenth, eleventh, and twelfth teeth are all close together and about equal in size, which is about that of the second or third

maxillary teeth. The maxillo-palatine suture extends directly inward from the palatine fenestra about one-third of the distance between this fenestra and the median line; it then curves sharply forward and meets its mate in a fairly sharp point on the midline at the level of the anterior border of the sixth maxillary tooth. About one-half of the external border and one-fifth of the internal border of each palatine fenestra are composed of the maxillary bone. The suture with the ectopterygoid begins at the level of tenth maxillary tooth and extends back a short distance behind the twelfth tooth.

NASALS.—The nasal bones are short and broad. They constrict slightly immediately behind the posterior processes of the premaxillaries but expand again near the anterior end of the contact with the lacrymals. The naso-lacrymal sutures extend straight back to the anterior end of the naso-prefrontal contact. The latter contacts converge slightly posteriorly. The naso-frontal contact is in the form of a broad V.

LACRYMALS.—These bones are relatively large, much larger, in fact, than the prefrontals. The length of the naso-lacrymal suture is relatively great, being about one-third as long as the maxillo-nasal suture. The lacrymals carry the preorbital ridges.

PREFRONTALS.—The prefrontals are relatively small; their length is considerable in proportion to their breadth. Each prefronto-lacrymal suture extends in a direct antero-posterior direction through the anterior two-thirds of its length; its posterior portion turns outward toward the inferior border of the orbit. The prefrontals carry the anterior portions of the supraorbital ridges.

FRONTAL.—The single frontal bone carries part of each supraorbital ridge; its anterior portion carries a small median elevation; this anterior process is about equal in length to the broader portion of the bone. The orbital borders of the frontal are very short. The suture with the parietal is not very distinct, but it appears to be anterior to the supratemporal fenestræ, the frontal not entering these cavities. The median postorbital portion of the bone is deeply sculptured.

POSTORBITALS.—The postorbital bones are not especially characteristic.

PARIETAL.—This is characterized by very deep sculpturing. It carries a pair of bony prominences back of the supratemporal fenestræ. It appears to reach the posterior border of the skull around the supra-occipital, but the sutures in this region are not distinct. The distance between the two supratemporal fenestræ is greater than the length of the fenestræ themselves.

SQUAMOSALS.—The squamosals are large and massive. The postero-external corners are elevated into prominent protuberances. The sutures with the exoccipitals are obscure.

SUPRAOCCIPITAL.—This bone appears to extend back a considerable distance on the superior surface of the skull; this cannot be determined accurately because of the obscure nature of the parieto-supraoccipital suture. The other sutures are equally obscure.

JUGALS.—These bones are not especially characteristic.

QUADRATO-JUGALS.—The quadrato-jugals lack the sharp antero-superior processes which are characteristic of *Crocodilus* and *Tomistoma*. They were probably present originally but have not been preserved. The bones are not especially characteristic.

QUADRATES.—The quadrate bones are not especially characteristic.

PALATINES.—The palatines are relatively short and broad. The maxillo-palatine suture has been described above. The palato-pterygoid suture bends forward as in *C. palustris*.

ECTOPTERYGOIDS.—The left ectopterygoid only is preserved, and it is not complete. The bone does not appear to be especially characteristic. The pterygo-ectopterygoid sutures divide the posterior borders of the palatine fenestræ into two equal portions.

EXOCCIPITALS, BASIOCCIPITAL, PERIOTICS, ALISPHENOIDS, AND BASISPHENOID.—None of these bones exhibit characters which are of sufficient value to require special description.

MEASUREMENTS

Length of Skull, Median	30.0 cm.
Breadth Across Premaxillaries	9.7
Length of Premaxillaries on Palate	6.4
Breadth Across Canine Groove	8.2
Length, Anterior End of Palatine to Premaxillary-maxillary Suture	6.4
Length, Anterior End of Palatine to Tip of Snout	12.1
Length, Anterior End of Palatine to Anterior End of Internal Nares	13.2
Length, Pmx.-Mx. Suture on Canine Groove to Anterior End of Ectopterygoid, Right Side	12.7
Breadth Across Last Alveoli	15.7
Length, Maxillary Alveolar Border, Left	15.0
Length, Maxillary Alveolar Border, Right	14.7
Length, Palatine Foramen, Left	8.5
Breadth, Palatine Foramen, Left	4.6
Breadth, Palatines at Maxillo-palatine Suture	4.5
Breadth Across Maxillaries at 6th Maxillary Tooth	13.7
Breadth Across Maxillaries Posterior to 7th Maxillary Tooth	13.5
Breadth Across Quadrates	21.3

Breadth Across Quadrato-jugals	23.1 (est.)
Breadth Across Posterior End of Cranial Table	13.8
Breadth Across Anterior End of Cranial Table	9.6
Length of Cranial Table	8.2
Length, Maxillo-nasal Suture, Left	5.3
Length, Maxillo-nasal Suture, Right	5.8
Length, Lacrymo-nasal Suture, Left	1.9
Length, Lacrymo-nasal Suture, Right	1.9
Length, Frontal Border of Orbit, Left	1.75
Length, Frontal Border of Orbit, Right	1.65
Length, Anterior End of Orbit to Posterior End of Cranial Table, Left	13.6
Length, Anterior End of Orbit to Posterior End of Cranial Table, Right	13.0
Length, External Nares	3.1
Breadth, External Nares	3.3
Breadth of Snout at Base	15.5
Length of Snout	18.7
Length, Anterior End of Orbit to Canine Groove, Left	13.2
Length, Anterior End of Orbit to Canine Groove, Right	13.3
Breadth Between Orbits	4.1
Breadth Across Preorbital Ridges	6.4
Breadth Across Orbits, Maximum	12.9
Breadth Across Supratemporal Fenestræ, Maximum	6.6
Breadth Between Supratemporal Fenestræ	1.8
Length, Anterior End of Orbit to Tip of Snout, Left, Perpendicular	18.9 (est.)
Length, Anterior End of Orbit to Tip of Snout, Left, Oblique	19.4
Length, Anterior End of Orbit to Tip of Snout, Right, Perpendicular	16.3 (est.)
Length, Anterior End of Orbit to Tip of Snout, Right, Oblique	17.6
Length, Orbit, Left	5.5
Length, Orbit, Right	5.4
Breadth Orbit, Left	5.2
Breadth, Orbit, Right	5.2
Length, Supratemporal Fenestra, Left, Oblique Maximum	3.3
Length, Supratemporal Fenestra, Right, Oblique, Maximum	3.1
Length, Infratemporal Fenestra, Left	2.5
Length, Infratemporal Fenestra, Right	2.3

REMARKS

The relations of this crocodile are unknown. The short, robust proportions, the transverse premaxillo-maxillary suture on the palate, and the relatively great breadth of the premaxillary bones suggest *C. palustris* and *C. rhombifer*. In other respects, however, this form differs considerably from either of these species. Until more is known of the adaptive, convergent, and palæotelic characters of the Crocodilia, it seems best to make no statement regarding the relationships of *Crocodylus robustus*.

PLATE IV

**Skull of *Crocodilus robustus* Vaillant and Grandidier
In the Museum of Comparative Zoology**

About three-tenths natural size

- Fig. 1. Lateral view, left side**
 - Fig. 2. Superior view**
 - Fig. 3. Inferior view**
- After Barbour**





**Article V.—SKULL CHARACTERS AND AFFINITIES OF THE
EXTINCT FLORIDA GAVIAL *GAVIALOSUCHUS*
AMERICANA (Sellards)¹**

BY CHARLES C. MOOK

PLATES V TO IX

Excavations for rock phosphate in the Miocene of Florida in the last few years have brought to light a considerable number of specimens of fossil crocodiles. Some of the specimens thus obtained by the Amalgamated Phosphate Company have been presented, through the good offices of its superintendent, Mr. Anton Schneider, by the company to The American Museum of Natural History. Others have been presented to the Florida Geological Survey, the United States National Museum, and the Museum of Comparative Zoology.

In 1915 Dr. E. H. Sellards² described the anterior portion of the snout of one of these crocodiles under the name *Tomistoma americana*. In 1916 he published further descriptions, chiefly of the mandibles.³ The American Museum collections include one nearly complete skull of this species (Amer. Mus. No. 5663) and the anterior portions of the skull and jaws of another specimen (Amer. Mus. No. 5662). This material is much more complete than the material described by Sellards and forms a better basis of comparison with other tomistomoid species.

In the general form of the skull and the arrangement of the sutures on the superior surface of the snout, this species bears considerable resemblance to the living *Tomistoma schlegelii* and to several known fossil species of *Tomistoma*. After careful examination of the type specimen (U. S. Nat. Mus. No. 8816) and the well-preserved skull in the American Museum (Amer. Mus. No. 5663) and comparison with specimens of *T. schlegelii* and with specimens and figures of fossil species of *Tomistoma*, it appears that these resemblances may be more or less superficial, and tend to distract the attention of the observer from differences which are perhaps more important. In the following description these resemblances and differences are analyzed, and an attempt is made to evaluate them correctly. The species is here referred to *Gavialosuchus* Toula and Kail.

¹Contributions to the Osteology, Affinities, and Distribution of the Crocodilia. No. 2.

²E. H. Sellards, 1915. A New Gavial from the Late Tertiary of Florida. Amer. Journ. Sci., (4) XL, pp. 135-138, 2 figs.

³E. H. Sellards, 1916. A New Tortoise and a Supplementary Note on the Gavial, *Tomistoma americana*. Amer. Journ. Sci., (4) XLII, pp. 235-240, 3 figs.

GENERAL FORM

As in *Tomistoma schlegelii*, the skull of *Gavialosuchus americana* is long and slender; it resembles the skull of the living *Crocodilus cataphractus* in many respects; it is much less slender than the skulls of *T. schlegelii*, *T. gavialoides* Andrews from the Eocene of Egypt, and the living gavial, *Garialis gangeticus*; it resembles more closely in this respect *T. calaritanus* Capellini from the Italian Tertiary and *Gavialosuchus eggenburgense* Toulou and Kail from the Miocene of Austria. It is decidedly broader than the skull of *T. schlegelii*, but is not so deep vertically, nor does the external surface of the snout roll under as in the latter species; crushing of the fossil specimens has probably had little or nothing to do with this character. The expansion of the snout posterior to the narial aperture is not gradual, as in typical species of *Tomistoma*, but irregular, the snout expanding and then contracting slightly, somewhat as in the typical crocodiles. The snout expands abruptly immediately posterior to the notches which received the fifth premaxillary teeth; posterior to this the sides remain parallel to the fourth maxillary teeth, where the snout expands abruptly again; the transverse diameter of the snout across the fifth maxillary teeth is much greater than across the fourth. Posterior to the fifth maxillary teeth the snout contracts gradually as far back as the space between the seventh and eighth maxillary teeth; then it expands suddenly and continues to expand steadily from the eighth maxillary teeth to the fourteenth, or last; posterior to the last maxillary teeth is a slight constriction, and then a steady expansion behind the orbits; the quadrate region is not preserved.

The cranial table is considerably broader than long, and is almost rectangular in form. It is relatively large in size, considerably surpassing, in this respect, other tomistomoid species except *G. eggenburgense*.

The breadth of the skull is great in proportion to its vertical height.

CAVITIES OF THE SKULL

SUPRATEMPORAL FENESTRÆ.—The supratemporal fenestræ in this species are very large; they are oval in outline and are broader than long, also close together. In their form these fenestræ differ from the fenestræ of the various species of *Tomistoma*; they resemble those of *Gavialosuchus eggenburgense*. In size they resemble the fenestræ of *T. gavialoides* Andrews and *T. africanum* Andrews, and differ from the existing *Tomistoma* and from *T. calaritanus* Capellini. Each fenestra is larger than the narial opening and is about the same size as the orbit.

ORBITS.—The orbits are widely separated. They are rather large in size, and their axes of greatest length converge anteriorly; their diameters from the antero-internal to the postero-external ends are considerably greater than from the antero-external to the postero-internal sides.

NASAL ORIFICE.—The nasal orifice is large; it has a straight transverse anterior border; its lateral borders are curved and converge slightly in the posterior direction; the narrow posterior border is smoothly rounded.

PREMAXILLARY FORAMEN.—This opening is small, but not so small as in *Tomistoma schlegelii*; it is irregularly elongate in outline, resembling that of *T. calaritanus*.

PALATINE FENESTRÆ.—The borders of the palatine fenestræ are incompletely preserved. They extend as far forward as the anterior edges of the eleventh maxillary teeth.

THE BONES IN DETAIL

PREMAXILLARIES.—The premaxillaries do not extend as far back on the surface of the skull as in the recent *Tomistoma*. They extend as far back as the level of the third maxillary teeth on the superior surface and slightly farther back on the palate. They are longer in proportion to the length of the maxillaries than in *T. schlegelii* when measured along the sides of the snout; their posterior processes are shorter than in the latter species. Along the median line the two premaxillaries have a contact with each other, which is proportionally less than one-half the length of the same contact in the living *Tomistoma*. The premaxillo-nasal suture is nearly four times as long as in *T. schlegelii*.

Each premaxillary contains five teeth, differing in this respect from *T. schlegelii* and *T. gavia* and agreeing with *T. africanum*, *T. calaritanus*, and probably *G. eggenburgense*. None of these teeth are especially weak, though the second is the smallest, the first and fifth next in size, and the third and fourth largest. The full development of the second premaxillary tooth is a primitive character. All of these teeth are much larger than the premaxillary teeth of the existing species, and they are spaced somewhat differently. The first and second are rather far apart, and there is no prominent excavation posterior to the first for reception of the first mandibular tooth as in the modern species. (In one of the specimens in the collection of the Florida Geological Survey, Fla. Geol. Surv. No. 6158, there is a somewhat more prominent excavation,

according to Sellards¹); the second is close to the third, which is the homologue of the second of *T. schlegelii*; the third is widely spaced from the fourth, corresponding to the wide spacing of the second and third of the modern *Tomistoma*; the fourth and fifth are relatively close together, contrasting with the wide spacing between the third and fourth teeth in the existing species of *Tomistoma*.

The suture of the premaxillaries with the maxillaries on the palate is shaped quite differently from the same suture in *T. schlegelii* and resembles more that of *T. gavioloides* and *G. eggenburgense*. In the living *Tomistoma* the suture is W-shaped, with the central point of the W directed forward; in *T. calaritanus* it is irregularly W-shaped in the reverse direction; in *T. gavioloides* it is a simple acute V, directed backward; in *G. eggenburgense* it is a modified W, with the center of the W directed backward, complicated by a slight indentation at the median line, and with the internal bars of the W much greater than the external, so that the suture is nearly V-shaped. In the Florida species the suture extends slightly inward from the lateral border of the skull, then almost directly backward to a point opposite the space between the first and second maxillary teeth, then more nearly inward a very short distance, then almost directly backward but very slightly inward to the median line at a point slightly anterior to the third maxillary teeth, and thence in reverse direction to the external border of the skull on the opposite side.

MAXILLARIES.—The maxillary bones are of about the same length as in *T. schlegelii*. The maxillo-nasal sutures are similar in shape to those of the latter species, but are much longer proportionally. The form of the maxillo-lacrymal suture is not discernible at the contact with the nasals; the lower part of the suture is not characteristic in form; the same is true of the maxillo-jugal suture.

On the palate the maxillaries are very short along the median line; this is due to the considerable posterior extension of the premaxillaries and the anterior extension of the palatines. The sutures of the palatines extend forward in a sharp V, which reaches the median line slightly posterior to the level of the eighth maxillary teeth. The sutures with the ectopterygoids are situated at the level of the thirteenth maxillary teeth on the borders of the palatine fenestræ, then turn sharply backward to points slightly posterior to the fourteenth maxillary teeth, then turn outward and backward to the external border of the skull.

¹E. H. Sellards, 1915. A New Gavial from the Late Tertiary of Florida. Amer. Journ. Sci., (4) XL, pp. 135-138, 2 figs.

The teeth of the maxillaries, like those of the premaxillaries, are very large; they are much larger than the teeth of any species of *Tomistoma*, except perhaps *T. kerunense* Andrews, and resemble the teeth of *G. eggenburgense*. The first three teeth are about uniform in size and the fourth is smaller; the fifth is very large and the sixth is only slightly smaller than the fifth; the teeth posterior to the sixth are all large. So far as they are preserved, all of these teeth appear to be relatively short vertically, circular or elliptical in outline at the base, keeled very slightly on their edges in some cases; on a few teeth there are faint striations. They are not so sharp as the teeth of the modern species.

NASALS.—The nasals in this species are much longer than in the living *Tomistoma*; they extend to within a comparatively short distance from the narial aperture, as in *T. calaritanus* and *G. eggenburgense*. They resemble the nasals of the latter species and differ from those of *T. calaritanus* in that they do not extend as far forward as the premaxillo-maxillary sutures at the lateral borders of the skull; the anterior tips are slightly anterior in position to the level of the first maxillary teeth. The anterior portions of the nasals, between the premaxillaries, widen rapidly in the posterior direction; the larger portions, between the maxillaries, widen very gradually, much more so than in *T. schlegelii*. The greatest breadth of the nasals is at the level of the eleventh maxillary teeth; the breadth is about the same as in the recent form. The sutures with the lacrymals and maxillaries are evidently longer than in the modern *Tomistoma*. The naso-lacrymal sutures are not wholly preserved; from the parts which are preserved they do not appear to be characteristic in outline. The sutures with the prefrontals are shorter and much simpler than in the recent *Tomistoma*, consisting of obliquely placed straight lines. The contact with the frontal is also very short; the processes of the nasals, which wedge in between the prefrontals and frontal, are short and broad.

PREFRONTALS.—The prefrontals are relatively small in size; they have no anterior processes wedging in between posterior processes of the nasals as in the living *Tomistoma*.

LACRYMALS.—The complete outlines of the lacrymal bones are not fully determinable, owing to incomplete preservation. It is clear, however, that they are relatively large and that they are broader than in the modern species.

JUGALS.—The jugals are only partly preserved, the posterior portions being missing. They are rather broad and are short antero-posteriorly. The sutures with the lacrymals are only one-half as long as in *T. schlegelii*.

FRONTAL.—The frontal bone is characteristic in outline. Its anterior process is about as long as in the modern form but is much broader and more blunt, wedging the nasals farther apart at their posterior ends. The interorbital and cranial portions of the frontal are also broad. The frontal bone resembles that of *G. eggenburgense* in form.

POSTORBITALS.—These bones are large in size. Their longitudinal and transverse diameters, also their vertical thicknesses, are considerably greater than in *T. schlegelii*. Their inferior processes are also very stout, but this may be partly due to a slight flattening of the skull.

SQUAMOSALS.—The squamosal bones are characterized by their relatively small size. They are about equal in surface area to the postorbitals; in most crocodilians, including the modern *Tomistoma*, the squamosals are larger than the postorbitals.

PARIETAL.—This bone is broader than in *T. schlegelii* but occupies a smaller area of the skull-top because of the large size of the supratemporal fenestræ. The entire posterior border of the superior surface of the skull between the squamosals, which is greater than in the recent *Tomistoma*, is composed entirely of the parietal, the supraoccipital being entirely excluded. There is no median posterior notch such as that which characterizes *T. schlegelii*.

SUPRAOCCIPITAL.—The supraoccipital bone is broad and is deep vertically; it evidently extended downward nearly to the foramen magnum. It is entirely confined to the posterior surface of the skull.

PALATINES.—The anterior processes of the palatines only are preserved. They differ from the palatines of the modern *Tomistoma* in extending forward as in the true crocodiles, instead of ending abruptly at or near the anterior end of the palatine fenestræ.

ECTOPTYRGIDS.—The right ectopterygoid is nearly complete in No. 5663; its chief characteristic is a great thickness of the neck of the vertical process.

MANDIBLE

The mandible is known from a considerable amount of material in the collection of the Florida Geological Survey. In the American Museum collections No. 5662 contains the anterior portion of the mandible of a large individual. In this specimen the teeth are large and distant from each other, as in the maxillary and premaxillary. The first mandibular teeth are large and spaced a considerable distance from each other; the second teeth are large and are distant from the first; the first and second teeth are bent out sharply from the borders of the jaw; this is

correlated with the absence of deeply excavated pits in the premaxillaries to receive the first mandibular teeth. The third teeth are relatively small and are moderately distant from the second in one direction and the fourth in the other; the fourth teeth (as judged from the alveoli) are large. The teeth from the fifth to the ninth, inclusive, are all large and far apart. From the tenth back they are all large and close together. The number of teeth in the mandible cannot be determined from this specimen; the latter has the sixteenth tooth preserved on the right side, with the alveolus of another posterior to it; the number of mandibular teeth must therefore have been at least seventeen. Sellards estimates the number to be seventeen or eighteen, basing the determination not on a single complete specimen but by comparison of a number of incomplete ones.

The symphysis extends to the twelfth teeth, contrasting with the condition in *T. schlegelii*, in which it extends to the fifteenth, and with *T. africanus*, in which it extends equally as far. The mandible is slender, with nearly parallel sides as far back as the tenth teeth; from this point it expands rapidly to the posterior end of the specimen. The splenial bones extend into the symphysis as far forward as the space between the seventh and eighth teeth; they occupy a little over one-third of the length of the symphysis.

REMARKS

This species resembles other tomistomoid species in many respects and differs in others. The greatest resemblance is with the species from the Miocene beds of Austria, described by Toulou and Kail under the name of *Gavialosuchus eggenburgense* and later referred by Lydekker to *Tomistoma*. In some characters, however, the Florida species differs from the latter and resembles typical species of *Tomistoma* more closely. The resemblances and differences between the Florida species and the other species are indicated in the accompanying table.

Whether or not the Florida species is to be referred to *Tomistoma* is a difficult problem. Analysis of the table and comparison of the characters lead to the conclusion that the species should be referred to *Gavialosuchus* Toulou and Kail, which genus is closely related to *Tomistoma* but is not identical with it. *Gavialosuchus* presents characters which are in some respects intermediate between *Tomistoma* and *Crocodylus*; in the totality of characters, of course, the resemblance to *Tomistoma* is the greater. *Gavialosuchus* may be considered as a more primitive genus than *Tomistoma*.

The skull of the genus *Gavialosuchus* differs from that of *Tomistoma* in being more robust throughout; it is broader in proportion to its length; the teeth are fewer in number and more widely spaced; the premaxillo-maxillary suture on the palate is more or less V-shaped, instead of W-shaped as in most species of *Tomistoma*; the maxillo-palatine suture is more elongate; the cranial table is larger, especially broader; the supratemporal fenestræ are larger, more oblique in position, and closer together; the vertical depth of the skull is not so great; the expansion of the snout is relatively more abrupt; the number of premaxillary teeth is five, instead of the four which is typical of *Tomistoma*; the premaxilla is excavated much less for the reception of the first mandibular teeth; the teeth are not set in cylinder-like processes of the jaws, with deep depressions between them. Some species of *Tomistoma* approach a few of these characters very closely.

The species *Gavialosuchus americana* (Sellards) differs from *G. eggenburgense* Toula and Kail, in the following characters: the snout expands abruptly at the fifth maxillary teeth; the postorbital bones are unusually large; the cranial table is very broad; the sides of the cranial table are parallel; the premaxillo-maxillary suture on the palate extends back to the level of the third maxillary teeth; the maxillo-palatine suture is decidedly elongate; the fifth maxillary teeth are considerably larger than the fourth. Of the two species, *G. americana* is evidently the more primitive.

MEASUREMENTS

Amer. Mus. No. 5663

Length of Skull, Extremities of Squamosals to Tip of Snout	90.0 cm.
Length of Skull, Median Line	86.0
Breadth Across Extremities of Squamosals	22.0
Breadth of Cranial Table	21.3
Length of Cranial Table	14.0
Breadth Across the Supratemporal Fenestræ	15.5
Breadth Between Supratemporal Fenestræ	1.5
Breadth Across Jugals, Estimated	33.3
Breadth Across Orbits	20.5
Breadth Between Orbits	5.2
Length of Posterior Border of Skull to Anterior End of Anterior Process of Frontal, Along Median Line	24.7
Total Length of Nasal Bone	46.2
Total Length of Premaxillaries, Superior Surface of Skull	29.8
Median Length of Premaxillaries, Superior Surface of Skull	10.8
Breadth of Snout Across Narial Opening	10.0

Breadth of Snout Across Notch at Premaxillo-maxillary Suture on Lateral Surfaces	7.8cm.
Breadth of Snout Across First Maxillary Teeth	10.5
Breadth of Snout Across Fifth Maxillary Teeth	13.6
Breadth of Snout Across Ninth Maxillary Teeth	17.0
Breadth of Snout Across Fourteenth Maxillary Teeth	25.0
Length of Dental Series of Maxillary, Right Side	47.3
Vertical Height of Skull, Lower Ends of Ectopterygoids to Cranial Table	17.2
Length of Premaxillaries on Palate	30.0
Length of Maxillaries Along Median Line on Palate	21.5
Diameter of Alveolus of Fifth Maxillary Tooth	3.2
Amer. Mus. No. 5662	
Length of Portion of Skull Preserved (About to Last Maxillary Teeth)	72.0
Breadth of Snout Opposite Narial Opening	11.6
Breadth of Snout Across Fifth Maxillary Teeth	14.2
Length of Portion of Mandibles Preserved (to Alveolus of Seventeenth tooth)	71.3
Length of Symphysis	51.2
Splenial Portion of Symphysis	17.5
Breadth of Mandibles at Ninth Teeth	10.1

PLATE V

Skull of *Gavialosuchus americana* (Sellards)

Amer. Mus. No 5663

One-tenth natural size

- A. Lateral view, left side**
- B. Inferior view**
- C. Superior view**



PLATE VI

Skull and Jaws of *Gavialosuchus americana* (Sellards)

Amer. Mus. No. 5662

One-fourth natural size

Superior view



PLATE VII

Skull of *Gavialosuchus americana* (Sellards)

Amer. Mus. No. 5662

One-fourth natural size

, Inferior view



PLATE VIII

Jaws of *Gavialosuchus americana* (Sellards)

Amer. Mus. No. 5662

One-fourth natural size

Superior view



PLATE IX

Snout of *Guvialosuchus americana* (Sellards)

U. S. Nat. Mus. No. 8816, type specimen

One-third natural size

***A.* Superior view**

***B.* Inferior view**



U. S. Nat. Mus. No. 8816. $\frac{1}{8}$

**Article VI.—*BRACHYGNATHOSUCHUS BRAZILIENSIS*, A NEW
FOSSIL CROCODILIAN FROM BRAZIL¹**

BY CHARLES C. MOOK

The bones which comprise the type material of the broad-jawed genus herein proposed, *Brachygnathosuchus*, were collected in the Upper Purús River, in western Brazil. They were found in silt in the river bed, and not in rock in place. The geological age of the material is therefore unknown. Associated with these bones in the collection, which is the property of Mr. S. H. Roper and is on deposit in The American Museum of Natural History, was a tooth of *Megamys* (?) and a humerus of a megalonychine ground-sloth, which are stated by Dr. Matthew to suggest Pliocene age. There is a reasonable possibility, therefore, that the crocodilian remains may also be Pliocene. The crocodilian remains consist of a portion of the right ramus of a lower jaw, two vertebral centra and another worn bone provisionally identified as a vertebral centrum, and a worn, flat bone provisionally identified as an eroded dermal plate.

The jaw fragment consists of a portion of the dentary bone only. It differs considerably from that of any other known crocodilian, and in some respects resembles, superficially at least, that of a dinosaur. In the totality of its characters, however, it is nearer the typical crocodilian jaw than any other, and is therefore referred to the Crocodilia.

The bone is large and massive, surpassing any other known crocodilian jaw in this respect. Eight complete alveoli are preserved, and borders of two more are indicated. The complete alveolus which lies nearest the anterior end contains the tubular root of a large tooth. This alveolus is smaller than the second complete one, which is huge in size. Posterior to the second the alveoli exhibit a progressive decrease in size; the alveoli themselves are round and are close together. The vertical diameter of the bone is much greater, and the transverse diameter is slightly greater at the anterior end of the bone than at the posterior. The dental series is close to the external border of the superior surface at the anterior end and rather near the internal border at the posterior end. This suggests that the dental series did not extend much farther back.

¹Contributions to the Osteology, Affinities, and Distribution of the Crocodilia. No. 3.

The anterior end of the jaw is not preserved, and the symphysis is lacking, but an expansion on the inferior border of the anterior end of the part of the bone preserved indicates that this is at or near the posterior end of the symphysis. The superior surface, both internal and external to the alveoli, is extensively pitted. External to the alveoli the pits extend down over the surface.

The bone differs from the dentaries of other Recent and fossil crocodiles in that the largest tooth is posterior to the symphysis (the missing teeth could hardly have been larger than that of the second complete alveolus of the specimen). In typical crocodiles and alligators the teeth increase gradually in size from the posterior direction as far forward as the fourth, which are never posterior to the symphysis. The specimen here described might be interpreted, of course, as having had the symphysis extending back only as far as the level of the second or third teeth. In any case, there was a pair of very large teeth slightly posterior to the symphysis; this is a departure from the normal crocodilian structure. The groove which lodged the anterior end of the splenial is deep.

The larger and better preserved of the two vertebral centra resembles the centra of the lumbar region of the modern procrocodyles in most respects. The anterior concavity is moderately deep and the posterior convexity is strongly rounded. The pedicles which supported the neural arch are rather high, and are situated nearer the concave than the convex end of the centrum. The latter differs from the normal crocodilian centrum in that its vertical diameter is greater than its transverse, resembling, in this respect, the typical centra of the dinosaurs. The inferior surface of the centrum is partly broken away, revealing an interior mass of coarsely spongy bone.

The other vertebra is fragmentary; it is broader than the one described above; one end of it is concave, otherwise its characters are not clearly determinable. It is clearly a vertebral centrum, however.

The bone mentioned above as provisionally identified as a vertebral centrum is very poorly preserved. It is longer than the two centra described above, otherwise its dimensions are similar. One end is very convexly rounded and is very smooth. The contacts of this rounded end with the other surfaces of the bone are largely eroded, but evidently they were sharp. The end of the bone opposite the convex one is not preserved. The surfaces between the two ends are partially preserved. They are composed of longitudinally striated bone; three sides are rounded and smooth; the other side is eroded deeply near the convex



Fig. 1. Right dentary of *Brachygnathosuchus brasiliensis*. Type specimen, on deposit in the American Museum. A, internal view, one-third natural size; B, superior view, two-ninths natural size; external view, one-third natural size.



Fig. 2. Lumbar vertebra of *Brachygnathosuchus brasiliensis*. Type specimen, on deposit in American Museum. One-half natural size, A, superior view; B, lateral view, left side.

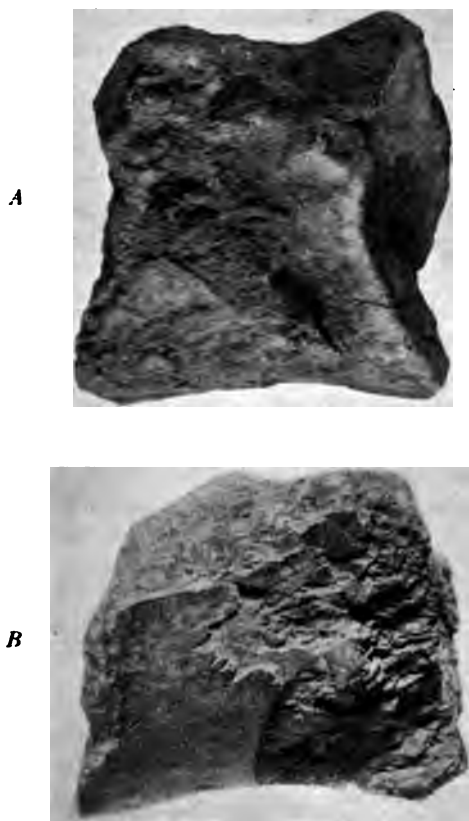


Fig. 3. Vertebral centrum of *Brachygnathosuchus brasiliensis*. Type specimen, on deposit in the American Museum. One-half natural size. *A*, superior view; *B*, lateral view.

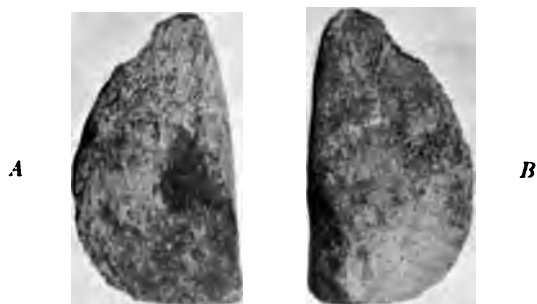


Fig. 4. Dermal scute of *Brachygnathosuchus brasiliensis*. Type specimen, on deposit in the American Museum. One-half natural size. *A*, internal view; *B*, external view.

end, but is somewhat elevated near the opposite end. If the bone is considered as a caudal centrum, the convex end would be the posterior end and the destroyed end the anterior end of the centrum. The elevated portion of the poorly preserved surface between the two ends would then be the base of the neural arch. The central portion of the centrum would then be considerably higher than broad, but the posterior end would be about equal in vertical and transverse diameters. Owing to the poor preservation of the bone, however, it is not possible to identify it positively.

Another bone in the collection which appears to belong with the remains described above is a flat solid bone, which is nearly straight on one side, the opposite being convexly curved; one end is straight and flat, and is perpendicular to the flat side; the other end is more nearly acuminate; the thickness is greater near the straight border than near the curved, and near the broad end than near the pointed end; one surface of the bone is very slightly concave, part of it in fact being flat, and the other convex. This bone is evidently a dermal scute that has been water-worn and has had its original rough surface destroyed.

MEASUREMENTS

Portion of Right Mandible Preserved, Length	.341M.
Portion of Right Mandible Preserved, Height	.186.
Portion of Right Mandible Preserved, Breadth, Minimum	.097
Seven Alveoli of Same, Total Length	.230
Length of First Complete Alveolus	.035
Breadth of First Complete Alveolus	.031 (est.)
Length of Second Simple Alveolus	.048
Breadth of Second Complete Alveolus	.046
Depth of Second Complete Alveolus	.110
Length of Eighth Complete Alveolus	.021
Breadth of Eighth Complete Alveolus	.018
Most complete Vertebral Centrum, Length	.130
The Same, Breadth, Anterior End	.084
The Same, Breadth Posterior End	.081
The Same, Breadth, Center	.065
The Same, Height, Total	.122
Fragmentary Vertebral Centrum, Length of Part Preserved	.101
Bone Provisionally Identified as a Vertebral Centrum, Length	.130
Dermal Scute, Length	.081
The same, Breadth	.047

The name **Brachygnathosuchus** is proposed, in reference to the short, stout character of the mandible.

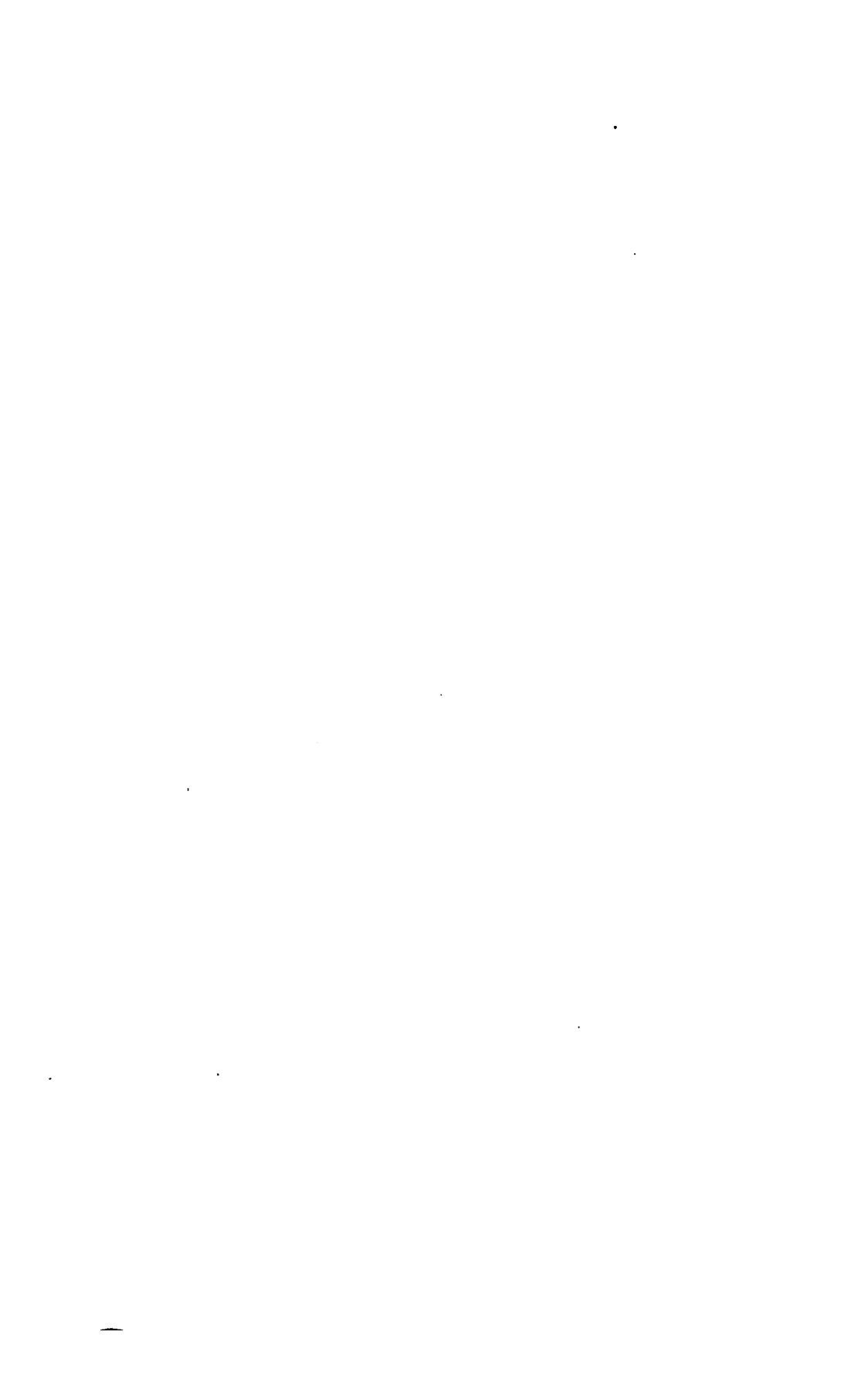
TYPE SPECIES.—*Brachygnathosuchus braziliensis*.

SUMMARY OF GENERIC CHARACTERS.—Mandible exceedingly short and broad; alveoli crossing rapidly from the external portion of the superior surface of the dentary near the anterior end to the internal portion of this surface slightly farther back; a very large tooth in the dentary slightly posterior to the symphysis; vertical depth of the anterior end of the dentary very great.

The name **braziliensis** is proposed for the species in reference to its general locality.

TYPE.—A portion of a right dentary, two vertebral centra, and two more or less problematical bones, provisionally identified as a vertebral centrum and a dermal scute. Property of Mr. S. H. Roper, on deposit in The American Museum of Natural History.

SUMMARY OF SPECIFIC CHARACTERS.—Size very great; steady decrease in the size of the teeth from the large postsymphysial tooth backward.



Article VII.—INDIVIDUAL AND AGE VARIATIONS IN THE SKULLS OF RECENT CROCODILIA¹

By CHARLES C. MOOK

PLATES X TO XII

In studying a collection of Pleistocene crocodiles from Cuba, considerable difficulty in the determination of species was encountered, through the wide range in some characters of the skulls, coupled with close similarities in other characters. It was first thought that many of the differences were of specific value, but closer study has suggested that they are due rather to individual variation or age variation or, more probably, both. In order to determine the value of variations of this sort the writer has studied a large series of Recent crocodilian skulls. The material available included an extensive collection in The American Museum of Natural History; another large collection, particularly rich in the less common species, in the Museum of Comparative Zoology, made available for study by Dr. Thomas Barbour; and several skulls of South American crocodiles belonging to the collections of the Museum of the University of Michigan, loaned by Dr. A. G. Ruthven. The material consisted of the following skulls: *Crocodylus americanus*, a large series, ranging from 6.3 cm. to 73.5 cm. in length; a series of skulls of *Alligator mississippiensis* ranging from 3.7 cm. to 49.0 cm. in length; and a series of skulls of *Caiman sclerops* ranging from 12.7 cm. to 23.5 cm.; also several individuals each of *Tomistoma schlegelii* and *Crocodylus porosus*.

In this study an attempt was made to separate age variations from those which are entirely individual; this was difficult, owing to the intergradation of the two types of characters. The results may be only approximate, but they do indicate the trend of variation among different individuals of the same age and of variations depending upon the age of the individuals.

AGE CHARACTERS

The age characters have been determined by comparison of series of individuals of various sizes in a number of species. Many of them are the same in all of the species studied; others are peculiar to certain species; the application of the latter sort is of course much more limited than the former.

¹Contributions to the Osteology, Affinities, and Distribution of the Crocodilia. No. 4.

1. PROPORTIONAL RELATIONS OF LENGTH TO BREADTH.—The relative proportions of length to breadth vary considerably with age, also to a certain extent among individuals of the same age.

In a large series of individuals the measurements and ratios of breadth over length are as follows:

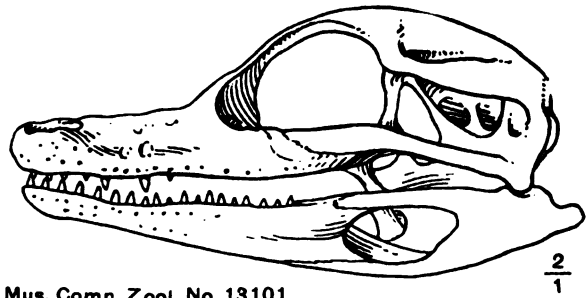


Fig. 1. Skull of a very young alligator (*Alligator mississippiensis*). Mus. Comp. Zool. No. 13101. Twice natural size. Lateral view, left side.

<i>Crocodylus americanus</i>			
	Length, Supraoccipital to Snout	Breadth, Across Quad- ratojugals	Ratio
Mus. Comp. Zool. No. 5002	6.3cm.	2.7cm.	.428
Mus. Comp. Zool. No. 5008	8.8	3.9	.443
Mus. Comp. Zool. No. 5007	11.6	5.0	.431
Amer. Mus. No. 15182	19.3	8.4	.430
Mus. Comp. Zool. No. 5032	22.0	10.2	.463
Amer. Mus. No. 15175	30.8	14.9	.483
Amer. Mus. No. 7120	37.9	19.35	.510
Amer. Mus. No. 7132	39.5	18.3	.462
Amer. Mus. No. 7121	40.3	20.0	.496
Mus. Comp. Zool. No. 5391	45.5	22.9	.503
Mus. Comp. Zool. No. 10921	49.1	29.2	.594
Mus. Comp. Zool. No. 13104	57.0	33.4	.585
Amer. Mus. No. 7139	73.5	36.8	.500
<i>Caiman sclerops</i>			
Mus. Comp. Zool. No. 5082	12.55	7.4	.589
Amer. Mus. No. 5239	13.35	8.2	.614
Mus. Univ. Mich. No. 53113	14.9	8.5	.570
Mus. Univ. Mich. No. 53112	17.8	10.0	.561
Mus. Comp. Zool. No. 5031	18.75	10.95	.584
Amer. Mus. No. 15184	19.6	12.4	.632
Amer. Mus. No. 15183	24.8	16.2	.653

Alligator mississippiensis

	Length, Supraoccipital to Snout	Breadth, Across Quad- rato jugals	Ratio
Mus. Comp. Zool. No. 13101	3.53cm.	1.98cm.	.560
Mus. Comp. Zool. No. 13102	3.95	2.13	.539
Amer. Mus. No. 2321	5.3	2.75	.518
Amer. Mus. No. 2320	5.7	3.02	.529
Mus. Comp. Zool. No. 13103	9.65	4.80(est.)	.496
Amer. Mus. No. 12752	19.35	9.80	.506
Amer. Mus. No. 7130	32.9	18.1	.550
Amer. Mus. No. 15178	33.9	18.6(est.)	.548
Amer. Mus. No. 15181	48.8	25.0	.512

This indicates that in *Crocodylus americanus* and *Caiman sclerops* there is a marked, though irregular, broadening of the skull with age. In *Alligator mississippiensis* there is only slight change from young to old, a slight narrowing being noticeable in the older specimens.

These comments are based upon the relations of the length to the breadth across the quadrato-jugals. If the breadth were taken across the snout, at the expansion near the fourth or fifth maxillary teeth, the results would be essentially the same, though differences might be noted in particular cases.



Amer. Mus. No. 7130

Fig. 2. Skull of an old crocodile (*Crocodylus americanus*). Amer. Mus. No. 7130. One-tenth natural size. Lateral view, left side.

2. PROPORTIONAL RELATIONS OF PREORBITAL AND ORBITAL-POSTORBITAL REGIONS.—In all young crocodilians the preorbital, or facial, regions are short compared with the postorbital, or cranial, regions; in some cases the facial regions are actually shorter than the cranial. In each of the existing species of crocodiles the preorbital region, measured from the anterior end of the orbits to the tip of the snout, in the adult, is longer than the orbital-postorbital region, measured from the anterior ends of the orbits to the median point of the posterior border of the cranial table. In the gavial and other long-snouted forms

this relation is very marked; in the alligators and short-snouted caimans and crocodiles it is much less notable. The value of any given facio-cranial ratio as an age character depends, more or less, upon the form of the adult. In any case, the adult forms have the facial region longer than the cranial.

Crocodilus americanus

	Postorbital Region	Preorbital Region	Po. R. Pr. R.
Mus. Comp. Zool. No. 5002	3.0cm.	3.3cm.	.909
Mus. Comp. Zool. No. 5008	3.7	5.2	.711
Mus. Comp. Zool. No. 5007	4.5	7.0	.642
Amer. Mus. No. 15182	6.5	12.6	.515
Mus. Comp. Zool. No. 5032	7.2	14.8	.486
Amer. Mus. No. 15175	9.7	20.8	.466
Amer. Mus. No. 7120	11.8	26.0	.453
Amer. Mus. No. 7132	12.0	27.8	.431
Amer. Mus. No. 7121	12.2	28.1	.433
Mus. Comp. Zool. No. 5391	12.5(est.)	33.0	.378
Mus. Comp. Zool. No. 10921	16.5	33.0	.500
Mus. Comp. Zool. No. 13904	15.5	41.5(est.)	.373
Amer. Mus. No. 7139	17.0	53.0	.320

These figures (with the exception of Mus. Comp. Zool. No. 10921, which receives comment below) indicate a very marked increase in the preorbital region, compared with the orbital-postorbital region, during the growth of the American crocodile. The exception, noted above, occurs in a large specimen originally referred by Gundlach to *C. rhombifer*. Its departure from the normal condition may represent an extreme of individual variation, or perhaps a geographic variation. The range from very young to very old, in this character, is very marked, the cranial region being over nine-tenths of the length of the snout in the youngest specimen, and less than one-third in the oldest.

Caiman sclerops

	Postorbital Region	Preorbital Region	Po. R. Pr. R.
Mus. Comp. Zool. No. 5082	5.40cm.	6.80cm.	.794
Amer. Mus. No. 5239	5.90	7.50	.786
Mus. Univ. Mich. No. 53113	6.20	8.50	.729
Mus. Univ. Mich. No. 53112	7.00	10.50	.666
Mus. Comp. Zool. No. 5031	7.60	11.15	.681
Amer. Mus. No. 15184	7.90	11.40	.692
Amer. Mus. No. 15183	9.45	15.35	.622

In this species the relative elongation of the preorbital region with age is notable, but is not extreme as in *Crocodylus americanus*. This may be partly accounted for by the larger size and greater age of the smallest and youngest specimen compared with the smallest and youngest specimen of *C. americanus*. This qualification is not of great importance, however, as the progressive elongation of the snout from medium-sized to large individuals is much less than in the American crocodile. The largest skull in this series, while much smaller than several of the *C. americanus* skulls, is not far from the maximum size of the species.

Alligator mississippiensis

	Postorbital Region	Preorbital Region	Po. R. Pr. R.
Mus. Comp. Zool. No. 13101	2.2cm.	1.4cm.	1.507
Mus. Comp. Zool. No. 13102	2.3	1.45	1.586
Amer. Mus. No. 2321	2.8	2.4	1.166
Amer. Mus. No. 2320	3.05	2.7	1.129
Mus. Comp. Zool. No. 13103	4.7	5.0	.940
Amer. Mus. No. 12752	8.2	11.45	.716
Amer. Mus. No. 7130	11.4	21.5	.530
Amer. Mus. No. 15178	12.0	21.7	.552
Amer. Mus. No. 15181	15.1	34.0	.444

In this species, also, there is a progressive increase in the length of the facial region, as compared with the cranial region, during growth.

3. SIZE OF ORBITS.—The orbits in young crocodiles are relatively much larger than in full-grown ones. This character is quite marked and is independent of variations in size of orbits in different species.

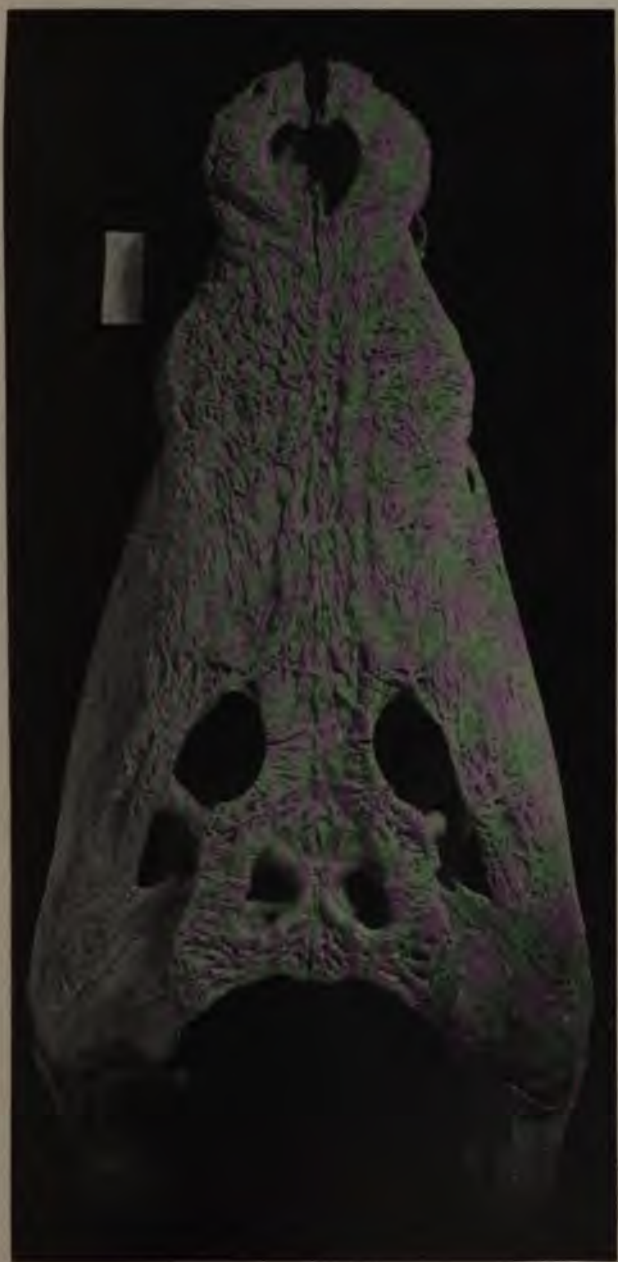
Crocodylus americanus

	Length, Supraoc- cipital to Snout	Breadth, Interorb- ital space	Length, Right Orbit	Breadth, Right Orbit	Ratio, Length Orbit Length Skull
Mus. Comp. Zool. No. 5002	6.3cm.	.38cm.	1.55cm.	1.25cm.	.246
Mus. Comp. Zool. No. 5008	8.8	.50	1.75	1.40	.198
Mus. Comp. Zool. No. 5007	11.6	.70	2.00	1.70	.172
Amer. Mus. No. 15182	19.3	1.50	2.80	2.22	.145
Mus. Comp. Zool. No. 5032	22.0	1.90	3.10	2.50	.140
Amer. Mus. No. 15175	30.8	3.00	4.7	3.5	.152
Amer. Mus. No. 7120	37.9	3.60	5.35	4.05	.141
Amer. Mus. No. 7132	39.5	4.05	4.80	3.50	.121
Amer. Mus. No. 7121	40.3	4.10	5.10	3.85	.126
Amer. Mus. No. 7139	73.5	6.85	6.50	5.10	.088



Amer. Mus. No. 7130.

Fig. 3. Skull of an old crocodile (*Crocodylus americanus*). About one-sixth natural size. Superior view.



Amer. Mus. No. 15179, 1/3.

Fig. 4. Skull of an old crocodile (*Crocodylus porosus*). Superior view.

Caiman sclerops

	Length, Supraoc- cipital to Snout	Breadth, Interorb- ital Space	Length, Right Orbit	Breadth, Right Orbit	Ratio, Length Orbit Length of Skull
Mus. Comp. Zool. No. 5082	12.55cm.	.85cm.	3.05cm.	2.35cm.	.243
Amer. Mus. No. 5239	13.35	.995	3.20	2.60	.232
Mus. Univ. Mich. No. 53113	14.90	1.00	3.30	2.70	.221
Mus. Comp. Zool. No. 5031	18.75	1.50	3.80	3.20	.202
Amer. Mus. No. 15184	19.60	1.95	3.80	3.20	.193
Amer. Mus. No. 15188	24.80	2.20	4.40	4.00	.177

Alligator mississippiensis

Mus. Comp. Zool. No. 13101	3.53	.25	1.05	1.00	.297
Mus. Comp. Zool. No. 13102	3.95	.30	1.20	1.10	.303
Amer. Mus. No. 2321	5.30	.35	1.55	1.30	.292
Amer. Mus. No. 2320	5.70	.40	1.70	1.35	.299
Mus. Comp. Zool. No. 13103	9.65	.70	2.50	1.80	.259
Amer. Mus. No. 12752	19.35	1.60	4.35	2.85	.224
Amer. Mus. No. 7130	32.9	2.70	6.20	4.20	.191
Amer. Mus. No. 15178	33.9	2.50	7.10	4.15	.209
Amer. Mus. No. 15181	48.8	4.55	7.80	4.70	.159

Correlated with the progressive reduction in the relative size of the orbits is a progressive increase in the relative breadth of the interorbital plate. In the North American crocodile the orbits do not change their relations of length to breadth to any considerable extent during growth. In *Caiman sclerops* the breadth of the orbits increases with age relatively faster than the length. In the alligator the orbit becomes relatively longer with age.

4. SIZE AND SHAPE OF THE SUPRATEMPORAL FENESTRÆ.—The supratemporal fenestræ are small and slit-like in the very young stages; in later stages they become rounder; in old ones they usually become small and nearly circular. The size of the fenestræ varies greatly among the different genera and species of crocodiles in the adult stages. In the common gavial (*Garialis indicus*) these fenestræ are very large; in most crocodiles they are small. In *Caiman trigonatus* they are absent, even in a comparatively young individual. In *Caiman sclerops* the size and shape of the fenestræ are definitely age characters and are important as such. The younger specimens have relatively large fenestræ (though they are smaller than those of the species of *Crocodilus*), the older ones have very small fenestræ, and in one old individual (Amer. Mus. No. 15183) the fenestræ are closed at the surface. The covering of the right fenestra

in this specimen is completely ossified; the left cover is ossified except for a minute area which is membranous. This indicates that decrease in size, and eventually complete obliteration, of the supratemporal fenestræ are characters associated with old age. In *Caiman trigonatus* and *C. palpebrosus* the process of closing the fenestræ appears to have been accelerated to such a degree that the condition produced has attained at least specific, perhaps even generic, value.

5. SPACING AND POSITION OF THE SUPRATEMPORAL FENESTRÆ AND RELATIVE SIZE OF CRANIAL TABLE.—In baby alligators and crocodiles the centers of the supratemporal fenestræ are immediately posterior to the centers of the orbits; the fenestræ themselves are widely spaced apart. In older, half-grown, individuals the centers of the fenestræ are posterior to the inner portions of the orbits; in all the crocodiles except the caimans the space between the fenestræ at this stage is relatively less than in very young individuals; in all of the old individuals studied, except the caimans, the fenestræ are close together, their centers being posterior to the inner borders of the orbits. The fenestræ thus appear to migrate inward during growth. Of course, the actual method of attaining this result is failure of growth between the fenestræ while growth was being accomplished rapidly in other regions.

Correlated with this apparent inward migration of the supratemporal fenestræ is the fact that the cranial table is relatively broader in young individuals than in old ones.

Crocodilus americanus

	Breadth, Across Quadrato-jugals	Breadth of Cranial Table	Ratios, Breadth of C. T. over Breadth of Quadrato-jugals
Mus. Comp. Zool. No. 5002	2.7cm.	2.12cm.	.785
Mus. Comp. Zool. No. 5008	3.9	2.70	.692
Mus. Comp. Zool. No. 5007	5.0	3.30	.660
Amer. Mus. No. 15182	8.4	5.00	.595
Mus. Comp. Zool. No. 5032	10.2	5.80	.568
Amer. Mus. No. 15175	14.9	8.40	.563
Amer. Mus. No. 7120	19.35	11.50	.594
Amer. Mus. No. 7132	18.30	12.30	.672
Amer. Mus. No. 7121	20.0	11.55	.577
Amer. Mus. No. 7139	36.8	18.15	.493

Caiman sclerops

	Breadth, Across Quadrato-jugals	Breadth, of Cranial	Ratios Breadth of C. T. over Breadth of Quadrato-jugals
Mus. Comp. Zool. No. 5082	7.4cm.	4.35cm.	.587
Amer. Mus. No. 5239	8.2	4.61	.562
Mus. Univ. Mich. No. 53113	8.5	5.20	.611
Mus. Univ. Mich. No. 53112	10.0	5.80	.580
Amer. Mus. No. 15185	10.1	5.85	.578
Mus. Comp. Zool. No. 5031	10.95	6.05	.552
Amer. Mus. No. 15184	12.4	7.28	.587
Amer. Mus. No. 15183	16.2	8.95	.552

Alligator mississippiensis

Mus. Comp. Zool. No. 13101	1.98	1.55	.782
Mus. Comp. Zool. No. 13102	2.13	1.65	.774
Amer. Mus. No. 2321	2.75	2.10	.763
Amer. Mus. No. 2320	3.02	2.25	.745
Mus. Comp. Zool. No. 13103	4.80(est.)	3.20	.666
Amer. Mus. No. 12752	9.80	5.62	.573
Amer. Mus. No. 7130	18.10	9.75	.538
Amer. Mus. No. 15178	18.60(est.)	9.70(est.)	.521
Amer. Mus. No. 15181	25.0	13.00	.520

In addition to the relative narrowing of the cranial table growth, a change in the shape of the table may be noted. In all of the very young specimens studied the posterior part of the cranial table is narrower than the central or anterior parts; in the older individuals the posterior portion of the cranial table is the broadest.

6. CHANGE OF SURFACE OF CRANIAL TABLE.—In all of the young specimens of *Crocodylus americanus* and *Alligator mississippiensis* studied the superior surface of the cranium is convex, and in figures of *Caiman sclerops* (none of the specimens available are young enough to show this character) the same appears to be true. In older individuals of all three species the cranial table is flat, and in one old individual of *C. americanus* (Amer. Mus. No. 7139) it is slightly concave. In two half-grown individuals of *C. porosus* (Amer. Mus. Nos. 7115 and 7131) the cranial table is slightly concave and in a very old individual (Amer. Mus. No. 15179) the table is very distinctly concave. In several species of crocodiles, both living and fossil, this condition appears to have been accelerated, comparatively young and small individuals having the cranial table concave.

7. SHAPE OF SNOUT.—In all the very young crocodilian skulls studied and in all figures of such skulls examined, the snouts are sharp-pointed and are triangular in outline. Their increase in length with age has been noted above. In all old individuals examined the snout has lost its early acute condition and become more or less rounded. The degree of this rounding depends upon the character of the snout in the various species. In some species the snout increases considerably in both length and breadth; in others the increase in length is much more rapid than the increase in breadth. In all young crocodilian skulls the superior surface of the snout is concave in antero-posterior profile. In many species the profile of the snout in the adult is convex, the change from the concave to convex condition being gradual; in other species the attaining of a convex profile appears to have been accelerated, so that a half-grown individual exhibits a marked degree of convexity; in still other species the profile remains concave throughout life.

8. NUMBER OF TEETH BENEATH THE ORBIT.—In their description of the skull of *Gavialosuchus eggenburgense* Toulou and Kail quote Burmeister as follows: "Je mehr Oberkieferzähne unter der Orbita stehen, desto jünger ist ein Krokodil." This statement is justified by the conditions noted in the series of specimens studied. The conditions in regard to the number of teeth under the orbit at various stages may be summarized in the following tables.

	Length of Skull	Number of Teeth Beneath Orbit	
		Right	Left
Mus. Comp. Zool. No. 5002	6.3cm.	5	5
Mus. Comp. Zool. No. 5008	8.8	5	5
Mus. Comp. Zool. No. 5007	11.6	4½	4
Amer. Mus. No. 15182	19.3	4	4
Mus. Comp. Zool. No. 5032	22.0	3½	3½
Amer. Mus. No. 15175	30.8	3	3
Amer. Mus. No. 7120	37.9	2	2½
Amer. Mus. No. 7132	39.5	1	1
Amer. Mus. No. 7121	40.3	1½	2
Amer. Mus. No. 7139	73.5	1	1

Caiman sclerops

	Length of Skull	Number of Teeth Beneath Orbit	
		Right	Left
Mus. Comp. Zool. No. 5082	12.55cm.	4	4
Amer. Mus. No. 5239	13.35	3½	3½
Mus. Univ. Mich. No. 53113	14.9	4	4
Mus. Univ. Mich. No. 53112	17.8	inc.	4
Mus. Comp. Zool. No. 5031	18.75	4	4
Amer. Mus. No. 15184	19.6	4½	4½
Amer. Mus. No. 15183	24.8	3½	3½

Alligator mississippiensis

Mus. Comp. Zool. No. 13102	3.95	7	7
Amer. Mus. No. 2321	5.30	5	5
Amer. Mus. No. 2320	5.70	5	5
Mus. Comp. Zool. No. 13103	9.65	4½	4½
Amer. Mus. No. 12752	19.35	3	3
Amer. Mus. No. 7130	32.9	0	0
Amer. Mus. No. 15178	33.9	½	0
Amer. Mus. No. 15181	48.8	0	0

Caiman niger

Mus. Comp. Zool. No. 4043	34.7	4	4
Amer. Mus. No. 15171	46.0	2	3

Tomistoma schlegelii

Mus. Comp. Zool. No. 12459	53.8	1	1
Amer. Mus. No. 15177	76.3	0	0

Crocodylus porosus

Amer. Mus. No. 7715	30.5	2	2
Amer. Mus. No. 7131	35.8	2½	1½
Amer. Mus. No. 15179	64.2	½	½

The general rule appears to hold among all of the species studied, except perhaps *Caiman sclerops*. In that species it is noticeable only to a very slight degree. This may be due partly to the fact that the species is a very short-snouted form, but mostly to the fact that the series studied contains no very young specimens, consequently the full range of variation is not ascertainable.

9. DEGREE OF LATERAL CONTRACTION OF THE SNOUT AND VERTICAL FLESTOONING OF THE SKULL AND JAWS.—In all young crocodiles the lateral borders of the snout are rather smooth, either as straight lines or as gentle curves. In older individuals the snout is usually contracted at one or more points. The degree of contraction varies greatly among the

various genera and species; for example, in the American alligator the amount of contraction is very slight, even in a very old specimen, while in old individuals of *Crocodilus porosus* the constrictions are very marked. In any particular species, however, the degree of contraction varies with age. In most crocodilian skulls there are two definite points at which these contractions may be found. One of those is immediately behind the last premaxillary teeth, where the premaxillo-maxillary sutures descend over the sides of the snout and where the fourth tooth of the lower jaw bites against the upper jaw. This constriction is very prominent in some species even at an early age, and Cuvier separated genera on the basis of this tooth biting into a notch, or constriction, outside the snout or in a pit on the under surface of the snout.

The correct evaluation of the condition of this constriction as an age character is rather difficult. In the alligators, in the caimans, and in the gavial it is never very prominent; in the true crocodiles it is very prominent in all the species at some stages but varies greatly among the species as to its condition at a particular stage. In all of the young specimens of *C. americanus* studied the notch is distinctly present, though the general outline of the snout is smooth; in older individuals of the same species the notch is equally prominent, if not more so; the same is true of the limited series of *C. porosus* skulls. In old individuals of some of the short-snouted species of *Crocodilus*, for example *C. palustris*, the notch is less prominent, the fourth mandibular teeth sometimes biting into pits as in the alligators instead of into notches. In the very young specimen which was used by Cope as the type of *Perosuchus fuscus* (Mus. Acad. Nat. Sci. Phila. No. 9720) it was noted by Fowler, who referred it to *Caiman sclerops*, as well as by Cope, that the fourth mandibular tooth on one side bit into a pit and on the other side into a notch. In the series of Pleistocene skulls from Cuba mentioned above, the younger individuals all have the notches deep with the fourth mandibular teeth biting into them, while the larger, older specimens have the constrictions less prominent and their fourth mandibular teeth bit into pits. Specimens of intermediate size show intermediate conditions, such as the fourth mandibular teeth biting partly into shallow pits and partly into notches, or on one side biting into a notch and on the other into a pit.

The difficulty of using the condition of this so-called "canine" notch as an age character is apparent. The present interpretation of this character is that in certain species which are known to be broad-snouted in old age one may expect the fourth mandibular tooth to grade from the normal crocodilian position in a notch to a position inter-

nal to the margin of the snout, biting into a pit. The presence of the pit may not mean a reduction of the constriction itself, but rather a general broadening of the snout. In some of the Pleistocene skulls from Cuba the fourth mandibular teeth bite into pits, but the constrictions are marked. In general it may be said that this constriction increases with age, but care must be taken in applying this rule to fossil forms whose specific habit is not known.

A second point at which the snout is usually somewhat constricted is in the region of the sixth or seventh maxillary teeth; the exact position varies somewhat among the different species of *Crocodylus* and considerably among the different genera, depending upon the member of the maxillary dental series which is largest in size. This constriction is usually very slight or absent altogether in the youngest stages, but with age it becomes more and more marked until in very old individuals it is usually very deep; this varies somewhat among the genera and species of crocodiles, but is true as a general statement of all of them except a few long-snouted forms such as *Garialis gangeticus* and *Tomistoma schlegelii*. In the last-mentioned species the snouts are characterized by special depressions between the teeth, differing somewhat from normal crocodilians.

The vertical looping, or festooning, which is notably characteristic of the crocodilian skull in general, varies directly, in its prominence, with the age of the individual. In very young individuals it is scarcely, if at all, noticeable; in old individuals, except those of the excessively long-snouted species it is very prominent. The festooning agrees with the lateral constricting in position. The vertical concavities of the borders of the premaxillaries and maxillaries coincide with the lateral constrictions, and the vertical convexities agree with the lateral expansions.

10. CRANIAL OVERHANG.—In all of the young skulls the cranial region is large in proportion to the anterior portion of the skull on the palatal aspect of the skull as well as on the superior aspect. In these skulls the basioccipital and basisphenoid bones occupy a considerable portion of the ventral surface, the posterior borders of the pterygoids being almost under the orbits, while in older skulls the occipital region is pushed farther back, the posterior borders of the pterygoids being far back of the level of the orbits.

11. OTHER CHARACTERS.—The pitting and the rugose condition of the surface of many of the bones of the crocodilian skull is greatly emphasized in old individuals. In all of the young skulls examined the surface is relatively smooth; in the individuals of medium size the

pitting is deeper and the surfaces rougher; in very old individuals, particularly those of *Crocodylus porosus*, the surface of the bone is exceedingly rough. The thickness of the bone also varies considerably with age. Specific characters, such as the oblique ridges in front of the orbits of *C. porosus*, the median elevation of the snout of *C. americanus*, and the facial ridges of some of the caimans, are usually emphasized in old individuals.

CHARACTERS OF GEOGRAPHIC VARIATION

A number of skulls examined possess characters which appear to be explainable best as geographic variation. A large series of skulls of the American alligator were seen to have certain areas variable in regard to the degree of pitting. Certain surfaces which in one group of skulls are smooth, in another group are distinctly pitted. There is no apparent transition from the strongly pitted to the smooth types, and the size was found to range considerably in both smooth and rough groups, so age has little to do with it. The large skull of *Crocodylus americanus* (Mus. Comp. Zool. No. 10921), which varied from others of the species in proportions as indicated in the foregoing tables, is known to have come from Cuba, while most of the skulls studied came from Florida. Another skull of the same species (Amer. Mus. No. 7121) varies somewhat in proportions from the remainder of the series. Several of the American crocodile skulls have the teeth directed sharply forward, while others have them extending vertically downward from the jaws. In the specimens of *Caiman sclerops* two individuals have the teeth of the mandible grouped in an abnormal manner, and the skulls themselves have somewhat unusual proportions. In none of these cases is there any appreciable degree of intergradation. It appears reasonable to suppose, considering that the latter species, at least, has a wide geographic range, that the variations noted may belong to different geographic varieties. In the absence of definite data as to the exact localities of a considerable number of the specimens, it is not practicable to treat this subject fully at the present time. It is mentioned to suggest a possible explanation of some of the items noted above.

INDIVIDUAL CHARACTERS

Among the skulls of several of the species variations were noted which certainly are not concerned with the age of the individuals and which do not appear to be definite enough to come under the head of geographic variations. Many of the irregularities of the tables of in-

crease or decrease of certain proportions with age, noted above, may be due merely to individual variation. Among these characters may be noted the following: variations in the size and direction of the teeth; unequal numbers of teeth on opposites of the same skull; variations in the contour of the snout; variations in the contour of the cranial table; variations in the form of certain sutures, particularly the premaxillo-maxillary suture on the palatal surface of the skull; the separation of the nasal bones from the narial aperture on the surface of the skull or the entrance of the nasals into this cavity at the surface; extent of piercing of the skull by mandibular teeth; the degree of excavation of the premaxillary and maxillary by the mandibular teeth and of the mandible by the teeth of the upper jaw; differences in the size of the prominences over the larger teeth; convergence or parallelism in direction of various borders, and many other characters of relatively small value and lack of uniformity or stability.

PLATE X

PLATE X
Skulls of *Crocodilus americanus*
One-sixth natural size
Superior views
From left to right
Amer. Mus. No. 7120
Amer. Mus. No. 15175
Mus. Comp. Zool. No. 5032
Amer. Mus. No. 15182
Mus. Comp. Zool. No. 5007
Mus. Comp. Zool. No. 5008
Mus. Comp. Zool. No. 5002

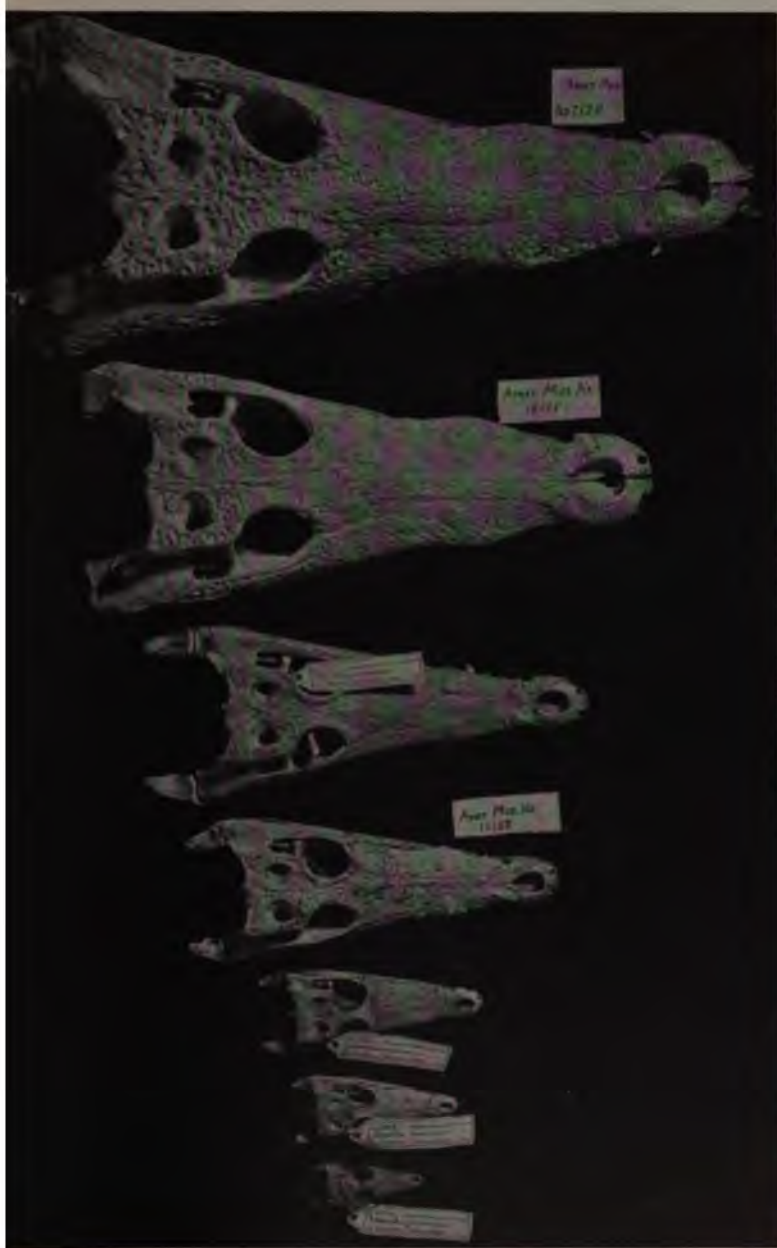


PLATE XI

Skulls of *Caiman sclerops*

One-fifth natural size

Superior views

From left to right

Amer. Mus. No. 15183

Amer. Mus. No. 15184

Mus. Comp. Zool. No. 5031

Mus. Univ. Mich. No. 63112

Mus. Univ. Mich. No. 53113

Amer. Mus. No. 5239

Mus. Comp. Zool. No. 5082

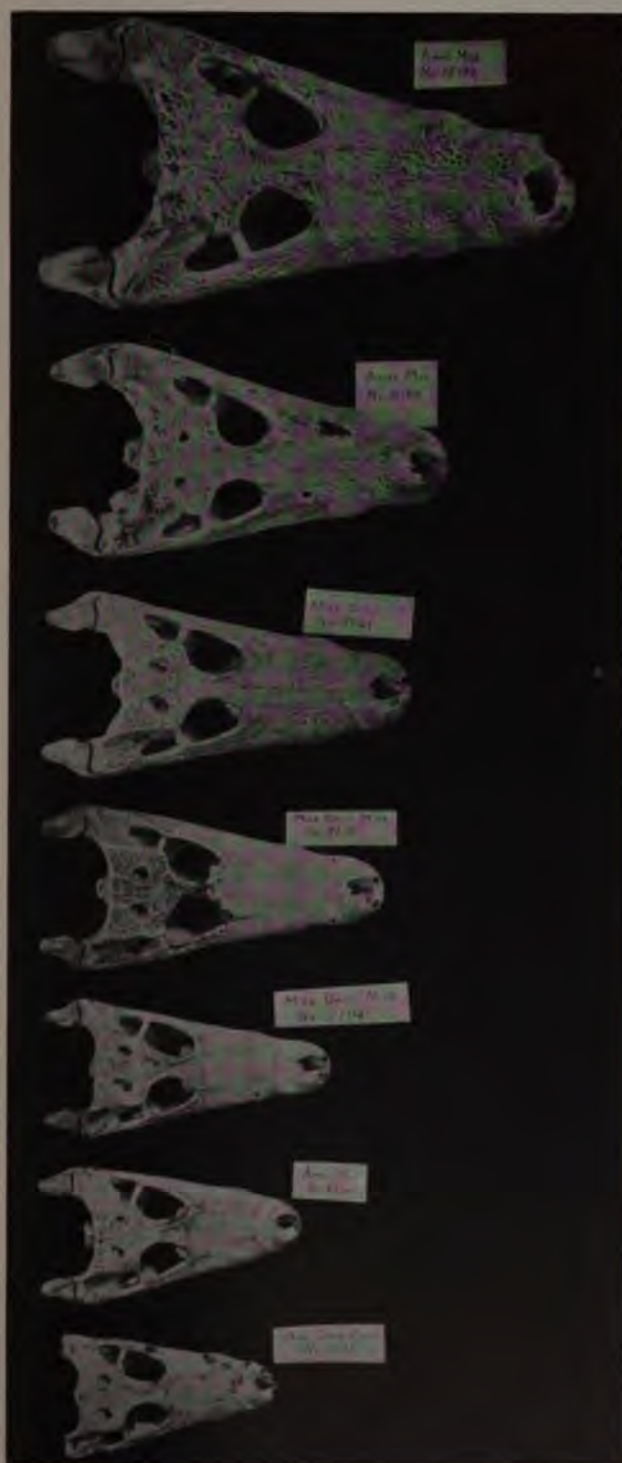


PLATE XII
Skulls of *Alligator mississippiensis*

One-fifth natural size

Superior views

From left to right

Amer. Mus. No. 15181

Amer. Mus. No. 15178

Amer. Mus. No. 12572

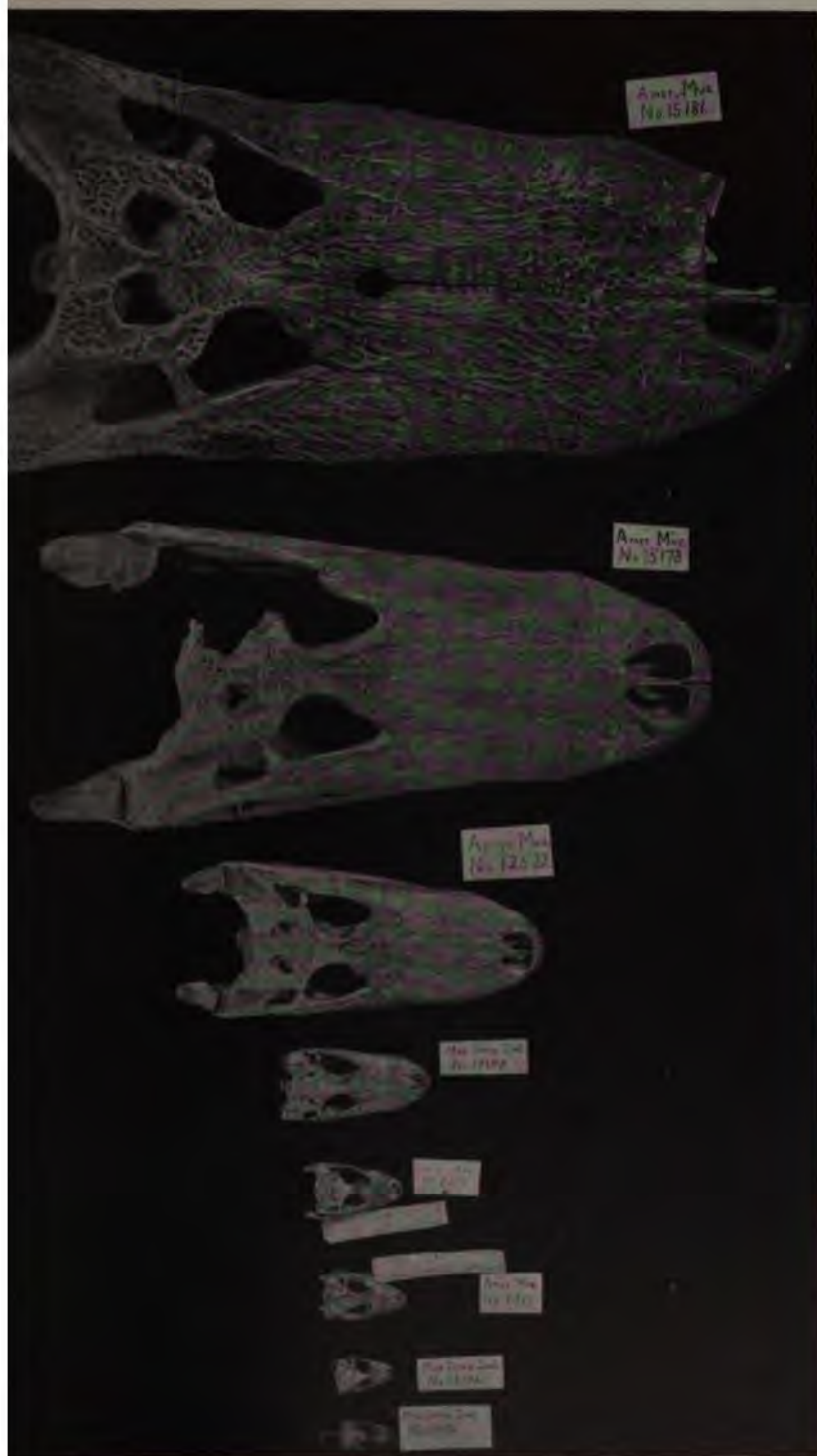
Mus. Comp. Zool. No. 13103

Amer. Mus. No. 2320

Amer. Mus. No. 2321

Mus. Comp. Zool. No. 13102

Mus. Comp. Zool. No. 13101



Article VIII.—NOTES ON THE POSTCRANIAL SKELETON IN THE CROCODILIA¹

BY CHARLES C. MOOK

PLATES XIII AND XIV

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INTRODUCTION

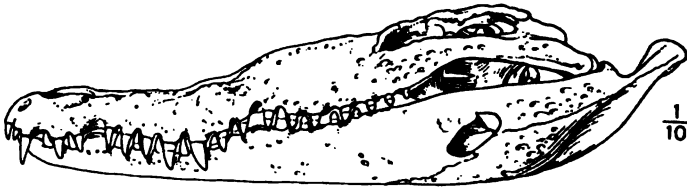
The following notes on the crocodilian skeleton are the result of a study of the skeletons of several of the genera of Recent crocodilians, made for the purpose of providing a basis of comparison for fossil material. The crocodilian skeleton has been described by Cuvier, Gadow, Brühl, Bronn, Reese, and others, but none of the descriptions by these writers are well adapted for comparison with fossil remains, which are often very incomplete. Many of these descriptions are highly valuable, however, and have proved very useful in the present study. The material which forms the basis of the present study consists, first, of a large, nearly complete skeleton of *Crocodylus americanus* in the American Museum collection (Amer. Mus. No. 7139), of which the vertebral column, ribs, pectoral, and pelvic bones, many of the limb bones, the chevrons, and part of the sternal apparatus, as well as the skull, are figured; second, a skeleton of *Tomistoma schlegelii* in the collection of the Museum of Comparative Zoology (Mus. Comp. Zool. No. 12459), a skeleton of *Caiman niger* (Mus. Comp. Zool. No. 4043), and a skeleton of

¹Contributions to the Osteology, Affinities, and Distribution of the Crocodilia. No. 5.

Alligator mississippiensis (Amer. Mus. No. 7130) which have been used for comparison with the American crocodile skeleton; third, a number of skeletons of *C. americanus*, *C. rhombifer*, *C. intermedius*.

CERVICAL VERTEBRÆ

PRO-ATLAS.—The pro-atlas is represented by a small V-shaped bone which is situated immediately posterior to the occiput, slightly above the foramen magnum; it has contact anteriorly with the supraoccipital of the skull, and antero-inferiorly with the exoccipitals; postero-inferiorly it rests upon the neural arch of the atlas. This element has been interpreted in a number of ways. It may represent a vestigial vertebra between the atlas and the skull, all of the components except this small remnant having vanished during the evolution of the group. Reese



Amer. Mus. No. 7139

Fig. 1. Skull of *Crocodilus americanus*. Amer. Mus. No. 7139. One-tenth natural size. Lateral view, left side. Introduced for comparison of size with postcranial bones.

states that the pro-atlas has been considered as a membrane bone; Gadow considers it as the detached neural spine of the atlas; Marsh figured a similar bone in the dinosaur "*Morosaurus*" as a "postoccipital bone." Of these various views the first-mentioned is probably the correct one, although the evidence in its favor is not conclusive.

ATLAS.—The atlas consists of the paired neural arches, or neural arch pedicles, and the intercentrum. The two neural arch elements are connected superiorly by cartilage, and in some specimens are fused into a single bone. These pedicles are connected with the axis by zygapophysial articulations; anteriorly they are overlapped by the pro-atlas in an articulation which allows free movement between the two bones. The pro-atlas is evidently fixed in position with respect to the skull. Postero-inferiorly and medially the two stout neural arch pedicles of the atlas unite with the odontoid process of the axis (which is morphologically the pleurocentrum of the atlas); inferiorly the pedicles of the atlas articulate directly with the intercentrum of the same vertebra. The latter articulation is very slight, the two elements barely

coming in contact. Antero-inferiorly the atlas neural arch pedicles articulate with the occipital condyle of the skull. The condyle articulates with four vertebral elements, namely, the two neural arch pedicles of the atlas, the intercentrum of the atlas, and the odontoid process of the axis.

Axis.—The axis vertebra is characteristic. In the large specimen figured (Amer. Mus. No. 7139) the neural arch, odontoid process, and intercentrum are all united by open sutures only.

The **SPINE** is very low vertically and long antero-posteriorly. It projects backward beyond the postzygapophyses and terminates slightly above their level; anteriorly it projects forward beyond the limits of the neural arch proper but not quite so far as the prezygapophyses, termina-

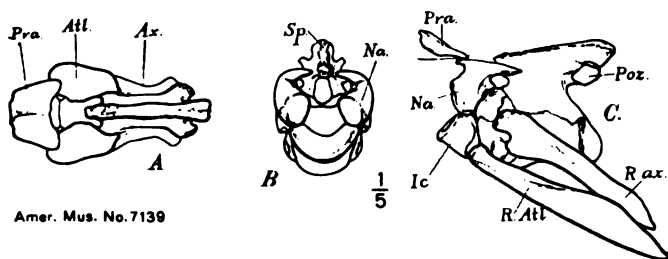


Fig. 2. Proatlas, atlas, and axis of *Crocodilus americanus*. Amer. Mus. No. 7139. One-fifth natural size. A, superior view; B, anterior view; C, lateral view, left side. Atl., atlas; Ax., axis; Ic., intercentrum of atlas; Na., neural arch of atlas; Poz., postzygapophysis; Pra., pro-atlas; R. Atl., left rib of atlas; R. Ax., left rib of axis.

ting anteriorly at a level slightly higher than that of the prezygapophyses and at about the same level as the postzygapophyses. The antero-superior border of the spine is somewhat rugose and is slightly thickened.

The **PREZYGAPOPHYSES** are small. They are situated somewhat lower than the postzygapophyses but are not any closer together. The articular surfaces are very small and indistinct; the processes which support them are distinct, but, at the same time, small. The prezygapophyses face almost directly upward.

The **POSTZYGAPOPHYSES** are relatively large. They face obliquely downward and outward. They are situated relatively close together and partially upon free processes. They are higher in level than the prezygapophyses.

The **NEURAL ARCH PEDICLES** are low vertically and elongated antero-posteriorly. Their anterior portions, where they come in contact with the massive odontoid, are considerably thickened.

The RIB FACETS are peculiar in their positions. The tubercular, or diapophysial, facets are situated entirely on the odontoid process, which is morphologically a part of the atlas. The capitular, or parapophysial, facets are situated partly on the odontoid process, and partly on the centrum of the axis itself. The two processes are not far apart from each other. The greatest breadth of the vertebra is across the tubercular rib facets.

The NEURAL CANAL is large in diameter.

The ODONTOID PROCESS is large and prominent. It articulates with the neural arch and with the centrum by suture. Morphologically this process is the pleurocentrum of the atlas. The superior portion of the process is long antero-posteriorly; the inferior portion is short in that direction. The superior surface is marked by a conspicuous groove, which lodged the spinal cord. A broad antero-inferior surface is situated between the two tubercular rib facets and between the anterior ends of the capitular facets.

The CENTRUM (pleurocentrum) of the axis is slightly keeled inferiorly. The anterior end of the keel is slightly broadened and is rugose. The posterior end is strongly convex.

CERVICALS 3 TO 8 INCLUSIVE.—The cervical vertebræ posterior to the axis are characterized by great height in proportion to their breadth. They also possess very distinctive cervical ribs.

The SPINES are low and thick in the anterior direction in the anterior cervicals, increasing in height and decreasing in thickness on approaching the dorsal region. The anterior spines have single posterior edges; the posterior ones have two lateral flanges of bone on the posterior edges. The transition between the two types of edge is gradual.

The ZYGAPOPHYSES are small and close together anteriorly, and farther apart and broader posteriorly. This increase in size is fairly regular, but the regularity has one or two exceptions (see table of measurements).

The rib facets are small and rather far apart on Cervical 3; on Cervicals 4, 5, 6, and 7 they are larger and closer together; on Cervical 8 they are again smaller and far apart; the facets on each side of Cervical 8 are farther apart than those of any other cervical. The capitular facets are all situated on the centra; in Cervical 3 they are near the inferior border; they gradually rise in position in the cervical series, until in Cervical 8 they are near the superior border. The tubercular facets are situated on the ends of the transverse processes, or diapophyses. In Cervical 3 they are low in position, the processes projecting slightly

below the level of the neural arch-centrum sutures; the facets face obliquely outward and downward, and the processes are very short in this vertebra. There is a progressive rise in position, a progressive change in the form, and especially a progressive lengthening of the processes, until in Dorsal 1 the facets face directly outward and are situated high above the level of the neural arch-centrum sutures on long diapophyses.

All of the centra have very deep anterior cups and pronounced posterior balls. The inferior surface of each cervical centrum is strongly keeled, and the anterior portion of each keel is extended into a prominent downward-projecting process. This process is short and strongly rugose in the anterior portion of the cervical series, and is longer and smoother near the dorsals.

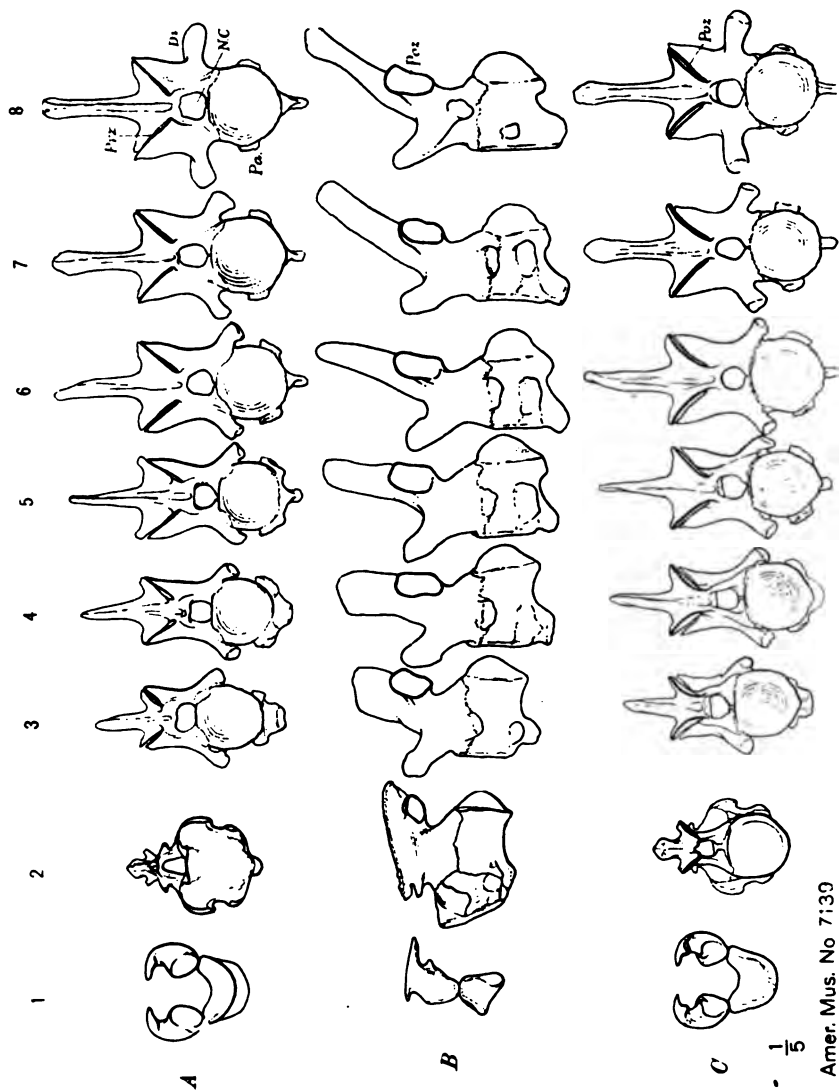
Measurements of Cervical Vertebrae (Amer. Mus. No. 7139)

	Length of Centrum	Breadth of Centrum, Anterior End	Height of Centrum, Anterior End	Spread of Prezyga- pophyses	Spread of Post- zygapophyses	Spread of Diapophy- ses	Spread of Para- pophyses	Height, Total
Cervical 2	9.45cm.	4.6cm.	4.6cm.	3.0cm.	3.3cm.	6.2cm.	5.3cm.	8.7cm.
" 3	6.7	4.0	4.0	4.0	4.1	6.55	3.55	12.7
" 4	6.8	4.3	4.1	4.4	4.9	6.6	4.9	14.0
" 5	6.6	4.4	4.1	5.4	5.4	7.0	5.5	15.6
" 6	6.5	4.4	4.7	6.1	5.8	7.8	5.8	16.6
" 7	6.4	5.2	4.8	6.4	6.4	8.9	6.3	16.7
" 8	6.55	5.6	4.6	6.85	6.35	11.2	6.45	17.5

DORSAL VERTEBRÆ

There are twelve, possibly thirteen, dorsal vertebrae in the large specimen (Amer. Mus. No. 7139), the uncertainty depending upon the identification of Post-cervical 13 as a dorsal or a lumbar. Thirteen is probably correct for the dorsals. The first two dorsals resemble the cervicals very closely in form, and the third resembles them somewhat.

The SPINES of the anterior dorsals are relatively high and narrow antero-posteriorly; they are thicker, however, than those of the posterior cervicals. Farther back they are lower and thicker. The posterior surfaces of the spines are all single and rugose.



Amer. Mus. No. 7139

Fig. 3. Cervical vertebrae of *Crocodilus americanus*. Amer. Mus. No. 7139. One-fifth natural size. A, anterior views; B, lateral views, left side; C, posterior views; 1-8, first to eighth cervical vertebrae, inclusive. Di., diapophysis; N. C., neural canal; Pa., parapophysis; Pos., postapophysis; Pra., preapophysis.

The ZYGAPOPHYSES have a greater transverse diameter than in the cervicals in the anterior dorsals, but are still relatively narrow. They broaden as far back as Dorsals 5 and 6 and then remain constant in breadth to the lumbar.

The DIAPOPHYSES increase steadily in length from Dorsal 1 to Dorsal 9, which is the longest. Posterior to this point the processes decrease slightly in length. The tubercular rib facets face directly outward.

Measurements of Dorsal Vertebrae (Amer. Mus. No. 7139)

	Length of Centrum	Breadth of Centrum, Anterior End	Height of Centrum, Anterior End	Spread of Prezygapophyses	Spread of Postzygapophyses	Spread of Diapophyses	Spread of Parapophyses	Height, Total
Dorsal 1	6.3cm.	5.4cm.	4.8cm.	6.8cm.	6.2cm.	12.9cm.	6.3cm.	18.0cm.
" 2	6.5	5.6	4.0	6.6	6.3	14.8	6.1	18.5
" 3	6.6	5.3	4.6	6.7	7.0	17.9	6.6	18.0
" 4	6.8	5.0	5.2	7.6	7.9	21.1	10.7	18.1
" 5	6.8	4.8	5.4	8.2	8.1	25.2	15.6	16.0
" 6	7.1	4.9	4.8	8.4	7.9	28.0	18.3	15.0
" 7	7.3	4.95	5.1	8.2	7.6	29.1	20.0	14.8
" 8	7.3	5.0	5.0	8.0	7.8	30.2	21.3	14.5
" 9	7.4	5.0	4.9	8.15	7.8	30.4	21.8	14.0
" 10	7.6	5.1	4.8	8.00	7.9	30.3	23.0	14.0
" 11	7.8	5.7	4.7	8.0	8.3	29.0	24.2	13.6
" 12	7.9	5.5	4.7	8.6	8.1	28.5	27.5	13.9
" 13	7.8	5.5	4.5	8.3	8.1	27.8	27.7	13.4

The CAPITULAR FACETS are situated on the centra in Dorsals 1 and 2. In both of these vertebrae they are carried on distinct parapophyses. In the third dorsal they are situated above the centrum and are farther apart. In this vertebra and in the vertebrae succeeding they are not carried on distinct parapophyses, but upon the diapophyses; they occupy notches which indent the anterior borders of these processes.

In Dorsal 3 the distance between the tubercular and capitular facets is greater than in any other vertebra. In Dorsal 4 the capitular facets are situated about half-way between the bases of the diapophyses and their distal ends; they are slightly lower in position than the tubercular facets. In Dorsal 5 the capitular facets are only slightly lower than

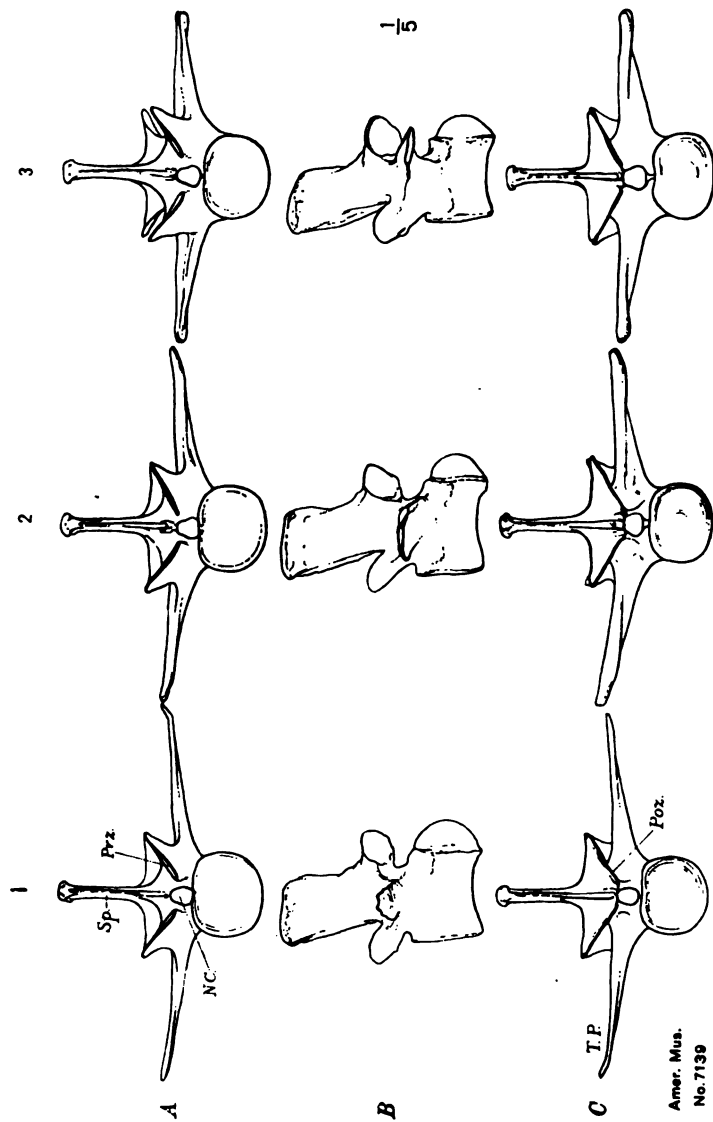


Fig. 4. Lumbar vertebrae of *Crocodilus americanus*. Amer. Mus. No. 7139. One-fifth natural size. A, anterior views; B, lateral views, left side; C, posterior views; 1-3, first to third lumbar vertebrae, inclusive. N. C., neural canal; Poz., postzygapophysis; Prz., presyngapophysis; Sp., spine; T. P., transverse process.

the tubercular facets and are closer to them than in Dorsal 4. In Dorsal 6 the capitular and tubercular facets are on the same level, and are closer together than in Dorsal 5. From Dorsal 7 to Dorsal 11, inclusive, the capitular facets are situated farther and farther out on the diapophyses, approaching the tubercular facets in position. In Dorsals 12 and 13 the tubercular and capitular facets cannot be distinguished from each other. In Dorsal 13 the combined facets are very small.

The CENTRA of all the dorsals are strongly and equally procœlous. In the first four dorsals the inferior surfaces are keeled, and have distinct inferior processes, like the cervicals. The centrum of Dorsal 5 is constricted somewhat inferiorly, but is not distinctly keeled. From Dorsal 5 back to the lumbar the inferior surfaces of the dorsal centra become progressively more and more broadly rounded.

LUMBAR VERTEBRÆ

There are three lumbar vertebræ. These resemble very closely the twelfth and thirteenth dorsals.

The SPINES are short; their antero-posterior diameters are slightly less than those of the posterior dorsals. The ZYGAPOPHYSES are very broad, being the broadest in the entire vertebral series. The DIAPOPHYSES are long, but less so than in the posterior dorsals. The length of the CENTRA is considerable, but is less than that of the posterior dorsals. They are strongly procœlous, as in the dorsals and cervicals, and are broadly rounded inferiorly.

Measurements of Lumbar Vertebræ (Amer. Mus. No. 7139)

	Length of Centrum	Breadth of Centrum, Anterior End	Height of Centrum, Anterior End	Spread of Prezygapophyses	Spread of Postzygapophyses	Spread of Diapophyses	Height, Total
Lumbar 1	7.7cm.	5.6cm.	4.4cm.	8.25cm.	8.1cm.	25.0cm.	13.3cm.
" 2	7.7	5.6	4.3	8.5	8.5	23.5	13.2
" 3	6.9	5.5	4.3	8.8	8.4	21.8	13.2

SACRAL VERTEBRÆ

The two sacral vertebræ are both stout. The SPINES are low and considerably extended antero-posteriorly. The PREZYGAPOPHYSES are broad on the first sacral and much narrower on the second. The POSTZYGAPOPHYSES are narrow in both sacrals. The TRANSVERSE PROCESSES are very stout. Those of the first sacral are considerably longer than those of the third lumbar or of the second sacral. The processes of both

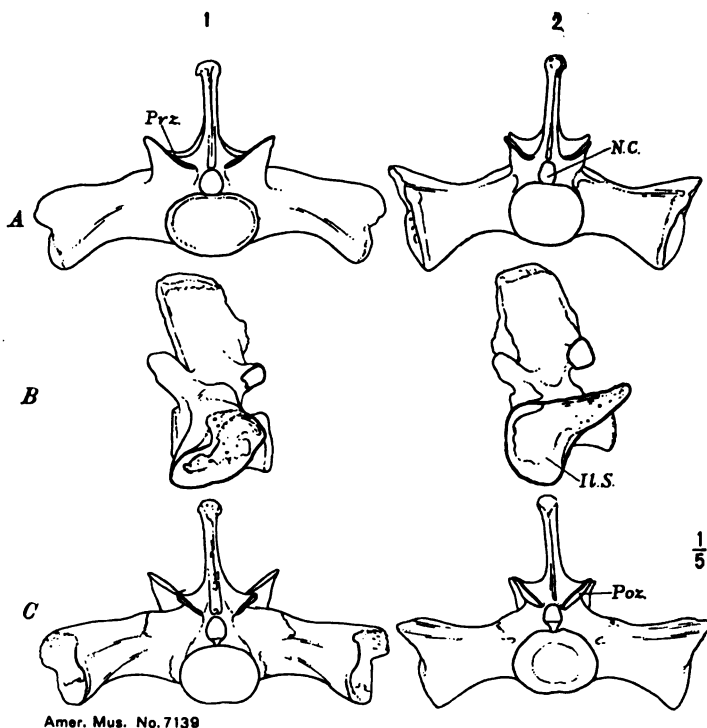


Fig. 5. Sacral vertebræ of *Crocodilus americanus*. Amer. Mus. No. 7139. One-fifth natural size. A, anterior views; B, lateral views, left side; C, posterior views; 1, 2, first and second sacral vertebrae respectively. I.L.S., iliac surface; N.C., neural canal; Poz., postsygapophysis; Prz., presygapophysis.

sacrals are expanded at their distal ends, those of the second much more so than those of the first sacral. The expansions are gradual and not abrupt. The articulations between the sacral processes and the ilia are complex and strong. The sutures between the free portions of these processes and their fixed bases indicate their morphological origin as ribs.

The CENTRA are relatively short. Their inferior surfaces are very broad; the inferior surface of the first sacral centrum is slightly grooved. The anterior surface of the centrum of the first sacral is concave; the posterior surface is nearly flat. The anterior surface of the second sacral centrum is nearly flat, and the posterior surface is concave.

Measurements of Sacral Vertebrae (Amer. Mus. No. 7139)

	Length of Centrum	Breadth of Centrum, Anterior End	Height of Centrum, Anterior End	Spread of Prezygapophyses	Spread of Postzygapophyses	Spread of Sacral Ribs	Height, Total, at Median Line	Height, Total, Including Extremities of Sacral Ribs
Sacral 1	5.9cm.	6.0cm.	4.0cm.	8.7cm.	5.25cm.	23.0cm.	12.6cm.	13.5cm.
" 2	6.2	5.0	3.8	5.5	5.35	20.2	12.5	14.2

CAUDAL VERTEBRÆ

The number of caudal vertebrae in the large specimen which comprises the chief basis of the present description (Amer. Mus. No. 7139) is thirty-seven. The number varies somewhat among the various species of crocodiles and also among the individuals of the same species.

The SPINES are of moderate height in the anterior caudals, increasing in length toward the mid-caudal region, the tallest spine being that of Caudal 18. From Caudal 18 back to the end of the tail the spines decrease steadily in height; the last four caudals have no spines, and the spine of Caudal 33 is vestigial. The anterior caudal spines are relatively thick antero-posteriorly. The spines gradually decrease in this respect until in the region from Caudal 14 to Caudal 24 they are very slender. Posterior to Caudal 24 they are slender, but are also very low, so their slenderness is not conspicuous. The spines of Caudals 2 to 7 have sharp posterior processes projecting back from their bases between the postzygapophyses.

TRANSVERSE PROCESSES are present in only the first fourteen caudals. They are long in the first and second caudals, and decrease in length regularly and rapidly in the posterior direction. There are faint traces

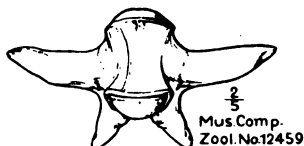


Fig. 6. First caudal vertebra of *Tomistoma schlegelii*. Mus. Comp. Zool. No. 12459. Two-fifths natural size. Inferior view. The sutures between the transverse processes and the centra indicate the costal nature of the processes.

Measurements of Caudal Vertebrae (Amer. Mus. No. 7139)

		Length of Centrum	Breadth of Centrum, Anterior End	Height of Centrum, Anterior End	Spread of Prezyga- pophyses	Spread of Postzy- gapophyses	Spread of Trans- verse Processes	Height, Total
Caudal	1	7.3cm.	5.1cm.	4.6cm.	5.85cm.	5.2cm.	19.6cm.	13.0cm.
"	2	6.9	5.0	4.3	5.95	4.8	19.5	13.4
"	3	7.0	4.55	4.4	5.4	4.3	18.6	13.5
"	4	7.3	4.6	4.2	5.0	4.0	17.5	13.5
"	5	7.5	4.45	4.1	4.65	3.85	16.6	13.6
"	6	7.6	4.3	3.85	4.50	3.60	15.7	13.0
"	7	6.7	4.05	3.70	4.20	3.20	14.1	13.25
"	8	7.7	4.40	4.40	3.7	2.95	13.05	11.8
"	9	6.8	3.45	3.65	3.7	3.20	12.0	10.3
"	10	7.8	3.55	3.30	3.65	3.20	11.8	10.15
"	11	7.7	3.35	3.05	3.8	2.7	12.0	10.00
"	12	7.4	3.2	2.9	3.4	2.7	10.7	10.70
"	13	7.8	3.2	2.8	3.3	2.35	8.85	10.40
"	14	7.5	3.1	2.6	2.8	2.5	4.45(inc.)	10.20
"	15	7.2	2.95	2.6	2.8	2.45		10.20
"	16	7.5	2.85	2.6	2.8	2.15		10.60
"	17	7.45	2.7	2.4	2.5	1.80		10.50
"	18	7.3	2.5	2.5	2.2	1.80		11.30
"	19	7.05	2.04	2.3	1.9	1.50		10.90
"	20	7.00	2.25	2.2	1.8	1.10		8.80(inc.)
"	21	6.6	2.10	2.00	1.50	1.15		9.6
"	22	6.6	2.00	2.00	1.45	.75		8.7
"	23	6.5	1.80	1.80	1.25	.50		8.2
"	24	6.3	2.00	1.80	1.05	.35		6.5
"	25	6.05	1.60	1.70	.95	.35		5.0(inc.)
"	26	5.90	1.50	1.50	.80	.25		5.0
"	27	5.70	1.35	1.40	.65	.10		4.2
"	28	5.30	1.30	1.20	.55	.10		3.5
"	29	4.90	1.20	1.10	.35	.10		
"	30	4.60	1.05	1.00	.25	.05		2.7
"	31	4.50	1.00	.90	.30	.30		2.25
"	32	3.40	.90	.80	.40(est)	.25(est)		
"	33	3.40	.75	1.10		.10		1.35
"	34	2.75	.50	.60				.70
"	35	2.05	.45	.50				.60
"	36	1.60	.30	.40				.50
"	37	1.80						

of a sutural connection of the free portions of the processes with their bases in the anterior caudals. This is usually not visible. In a specimen of *Tomistoma schlegelii* (Mus. Comp. Zool. No. 12459) the sutures are clearly visible. The presence of these sutures is an indication of the morphological origin of the processes as ribs.

The ZYGAPOPHYSES of the caudal vertebræ are relatively small and close together, compared with those of the lumbar and dorsals. They decrease in size gradually and steadily, ending in a tiny vestige in Caudal 36.

The CENTRUM of the first caudal is biconvex. The caudals from the second to the end of the tail have centra which are concave anteriorly and convex posteriorly. The degree of anterior concavity is much greater in the anterior caudal region than near the extremity of the tail, where the surfaces are nearly flat. In length the centra increase gradually, but irregularly, from Caudal 1 to Caudal 16, then decrease to the end of the tail. Caudal 37 is very slightly longer than Caudal 36, however. The inferior surfaces of the centra are smooth in the first two caudals. From Caudal 3 to the vicinity of Caudal 18 each inferior surface is characterized by two longitudinal, parallel, keel-like processes. Posterior to Caudal 18 these processes are separated into anterior and posterior portions by a central flat space.

CHEVRONS

Twenty-five chevrons are present in the large specimen measured. Other specimens have more or less than that number. The first chevron appears to articulate with the inferior surfaces of the second and third caudals at their junction with each other. The anterior chevrons have single articular surfaces and conspicuous foramina; farther back the chevrons are Y-shaped, having two articular processes; still farther back they lose the inferior processes and become V-shaped in cross-section, at the same time becoming more elongate antero-posteriorly. In form these chevrons bear a remarkable resemblance to those of the sauropod dinosaurs.

RIBS

The ribs of the Crocodilia are characteristic. The superior cervical and dorsal ribs are relatively stout and well ossified; those of the ventral series are slender and more or less cartilaginous. The double heads are very distinct in all of the superior ribs except those of the atlas and of the last two dorsal vertebræ. The number of ribs, both total and of

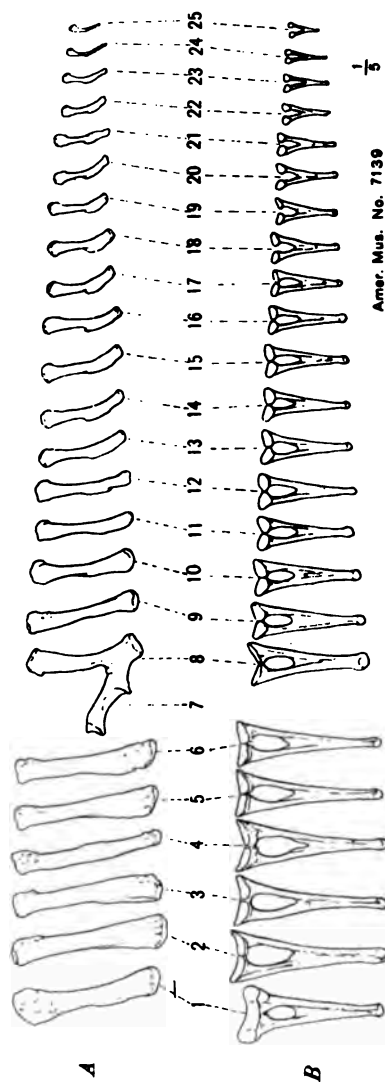


Fig. 7. Chevrone of *Crocodilus americanus*. Amer. Mus. No. 7139. One-fifth natural size. A, lateral views, left side; B, posterior views; 1-25, first to twenty-fifth chevrone respectively, as estimated.

the separate regions of the vertebral column, vary somewhat among the different genera and species. The transition in form from cervical ribs to dorsal ribs is more or less abrupt, though in some specimens the last cervical ribs are intermediate in character between typical cervical and typical dorsal ribs.

CERVICAL RIBS.—Each of the cervical vertebrae (except the problematical pro-atlas) bears a pair of ribs. The ribs of the atlas and axis are readily distinguishable from each other and from the remainder of the cervical ribs.

The ribs of the atlas are single-headed; they are long and flat, somewhat longer, in fact, than the ribs of the axis; their broadest portions are nearer the distal than the proximal ends; from their points of greatest breadth these ribs diminish in size rapidly to the slender extremities.

The ribs of the axis are intermediate in structure between those of the atlas and those of the post-axial cervicals. They are double-headed, and in most specimens one head is larger than the other. In the large specimen described (Amer. Mus. No. 7139) the tubercular facets and the processes which carry them are much larger than the capitular facets and their processes; the same is true of a smaller specimen of *C. americanus* studied (Amer. Mus. No. 15182); in some other specimens of the same species the two processes and their respective facets are equal in size. One specimen of *Caiman niger* (Mus. Comp. Zool. No. 4043) has the capitular elements larger in size than the tubercular. In *Tomistoma*, as shown by a young specimen (Mus. Comp. Zool. No. 12459), the tubercular portion of the axis rib is much greater than the capitular. In a small skeleton of *Crocodylus intermedius* (Amer. Mus. No. 8790) the capitular process is much larger than the tubercular. In *Osteolaemus tetraspis* (Amer. Mus. No. 4087) the same is true. In a medium-sized skeleton of *Crocodylus rhombifer* (Mus. Comp. Zool. No. 4042) the two processes are equal in size.

The ribs of the axis resemble those of the atlas in being long and flat; the point of greatest breadth in each rib is, however, at the capitular process, near the proximal end, and not below the center of the bone; the axis rib is slightly shorter than the atlas rib. Immediately below the capitular process the bone contracts somewhat, then remains practically uniform in breadth to a point very near the distal end, where it suddenly contracts.

The ribs of Cervicals 3 to 7 inclusive are very similar to each other, differing only in very slight characters. Each rib consists of a shaft which extends horizontally, parallel with the longitudinal axis of the

vertebral column, and the capitular and tubercular processes, which join the shaft almost perpendicularly. The lower, or capitular, process, is larger than the upper, or tubercular, process; the capitular articular surface is larger than the tubercular. The capitular process extends horizontally from the shaft to the parapophysis of the vertebra; the tubercular process extends obliquely upward to the diapophysis of the vertebra. The shaft extends both anterior to and posterior to the articular processes; in the third and fourth cervicals the anterior processes are considerably shorter than the posterior processes; in the fifth, sixth, and seventh cervicals they are only slightly shorter.

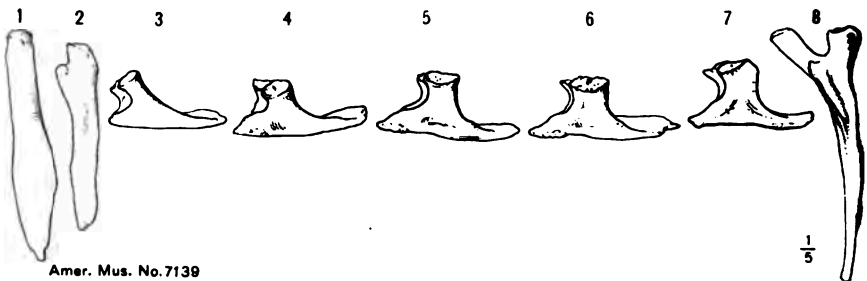


Fig. 8. Left cervical ribs of *Crocodilus americanus*. Amer. Mus. No. 7139. One-fifth natural size. Lateral views, 1-8, first to eighth ribs respectively.

The ribs of the eighth cervical are intermediate in form between typical cervical and typical dorsal ribs. They vary considerably among the genera and species of crocodilians. In *Crocodilus* and *Tomistoma* the eighth cervical ribs resemble the dorsal ribs closer than the other cervical ribs; in *Caiman* they are very close in form to the preceding cervical ribs; in *Alligator* they vary somewhat, in some specimens being long like dorsal ribs and in others short like typical cervical ribs. In all the specimens examined, however, they exhibit characters which are easily recognizable. They differ from typical cervical ribs in that their shafts are not perpendicular to the tubercular and capitular processes, but rather are extensions of them. The shaft of each is homologous with the posterior portion of the shaft of the typical cervical rib; it extends outward, downward, and backward in contrast with the longitudinal position of the typical shaft of a cervical rib. The anterior process of the shaft of the typical cervical rib is represented in the rib of Cervical 8 by a thin process, which extends forward from the shaft, below the articular processes; this thin process partly encloses a long round fossa on the anterior surface of the shaft. The tubercular process is shorter and thicker

than the capitular process. The rib is distinguishable from the dorsal ribs in general by the lesser length and the relatively acute termination of the shaft; it is distinguishable from the anterior dorsal ribs also by the lesser degree of curvature and by the smaller size of the articular processes and their closer proximity to each other; it may be distinguished from the mid-dorsal ribs by its lesser length and by its stouter and more prominent articular processes; it differs from the posterior dorsal ribs in being stouter and in having large, distinct articular processes.

DORSAL RIBS.—Considering Vertebra 9 as the first dorsal, there are thirteen pairs of dorsal ribs, including two pairs of floating ribs, in the large skeleton discussed (Amer. Mus. No. 7139); other skeletons possess only twelve dorsals.

The dorsal ribs are typically long, stout, and greatly curved, and have distinct tubercular and capitular facets (except in Dorsal Ribs 12 and 13). The first three dorsal ribs on each side have distinct capitular and tubercular processes; posterior to Dorsal Rib 3 the ribs have capitular processes only, the tubercular facets occupying the ends of the shafts without distinct processes. The two small posterior free ribs on each side possess no distinct articular processes and each has only one small articular surface.

The tubercular and capitular processes are far apart on Dorsal Rib 1, farther apart on Dorsal Rib 2, and still farther apart on Dorsal Rib 3; posterior to this point the tubercular processes disappear, and the articular surfaces approach each other until they merge together in the first free rib. In length the ribs increase steadily from Dorsal Rib 1 to a maximum in Dorsal Rib 8, then progressively decrease in length to the end of the costal series.

Several of the anterior dorsal ribs have prominent anterior processes for muscle attachment; these appear to be homologous with the anterior processes of the shafts of the cervical ribs. The number of ribs bearing these processes varies considerably among the various species of crocodiles, and among different individuals of the same species. In Amer. Mus. No. 7139 the first four dorsal ribs have this process strongly developed; it is absent altogether in Dorsal Rib 5. Other specimens of various species have only two or three dorsal ribs with these processes; the number appears to be somewhat greater in old individuals than in young ones. The distal extremities of all the dorsal ribs except the first are somewhat expanded. Some of the anterior dorsal ribs, usually the third, fourth, and fifth, plus a few others, carry uncinat processes; these are usually cartilaginous, but in some cases are slightly ossified. They are particularly noticeable in *Alligator*.

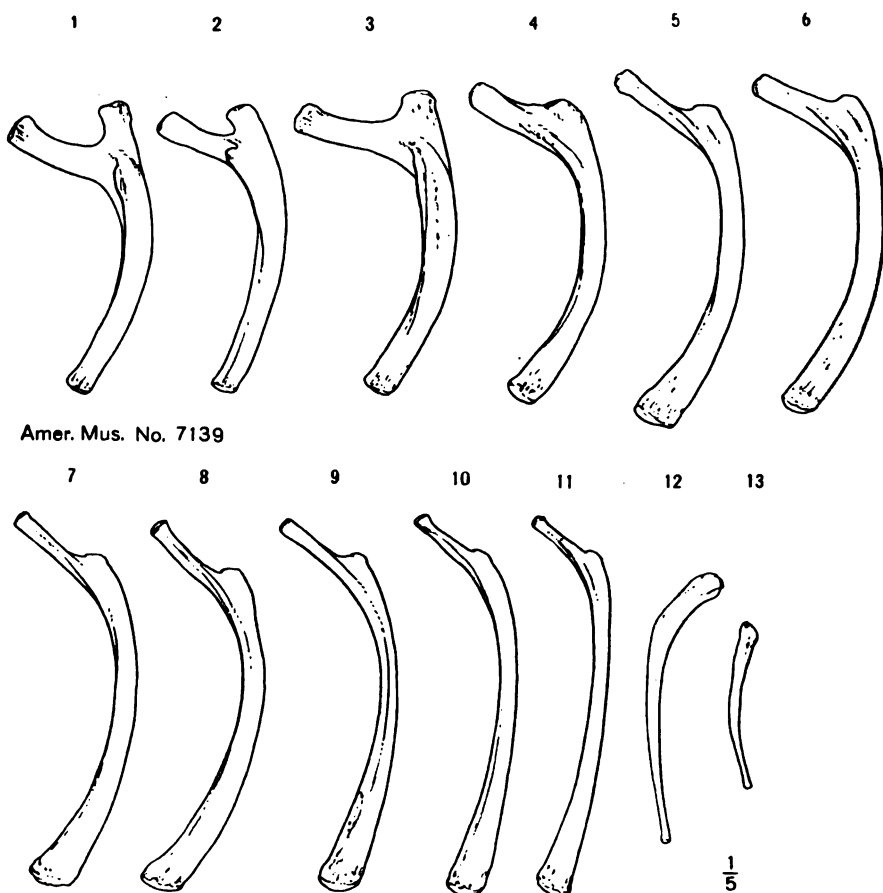


Fig. 9. Left dorsal ribs of *Crocodilus americanus*. Amer. Mus. No. 7139. External views. 1-13, first to thirteenth ribs, respectively, as estimated.

The posterior free ribs are small in size and simple in form; they are short and very slender, with acuminate extremities; they have no articular processes and but single simple articular surfaces; in cross-section they are almost circular.

Measurements

	CERVICAL RIBS			DORSAL RIBS	
	Length, Total	Breadth Across Capitular and Tubercular Processes		Length, Total	Breadth Across Capitular and Tubercular Processes
C. R. 1	15.4cm.	2.5cm.	D. R. 1	19.0cm.	6.40cm.
C. R. 2	12.1	4.3	D. R. 2	18.8	8.05
C. R. 3	7.7	4.0	D. R. 3	20.0	9.10
C. R. 4	8.5	3.7	D. R. 4	21.5	6.40
C. R. 5	9.4	3.7	D. R. 5	23.8	6.40
C. R. 6	9.1	4.2	D. R. 6	22.4	6.10
C. R. 7	8.2	5.5	D. R. 7	25.0	6.00
C. R. 8	17.1		D. R. 8	24.4	6.10
			D. R. 9	25.0	6.00
			D. R. 10	25.4	5.50
			D. R. 11	25.1	4.70
			D. R. 12	18.3	
			D. R. 13	11.0	

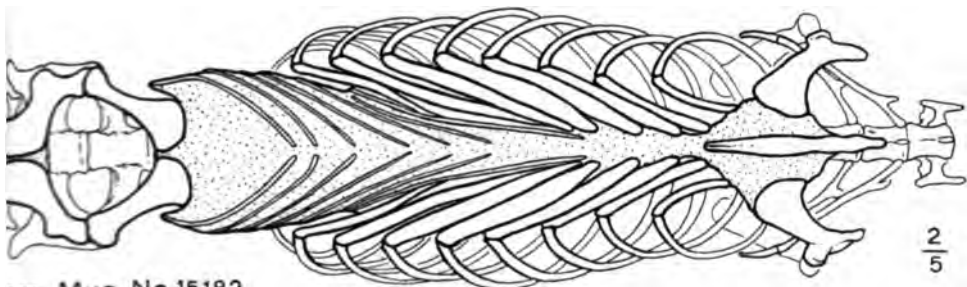


Fig. 10. Ventral view of portion of skeleton of *Crocodilus americanus*, indicating the positions of the ventral ribs. Mus. No. 15182. Two-fifths natural size. The dotted areas represent cartilage.

VENTRAL RIBS.—The system of ventral ribs in the crocodiles is complex. It consists of the ventral thoracic ribs proper, the bars connecting them with the dorsal ribs, and the abdominal ribs. Associated with these elements are the sternum and its associated structures. The

ventral thoracic ribs and the bars which connect them with the dorsal ribs are broad and flat; they are usually imperfectly ossified. The connecting bars extend downward and backward in direct line with the dorsal ribs; the ventral thoracic ribs extend inward and forward from the connecting bars to the sternal cartilage. The abdominal ribs are very large and are more perfectly ossified than the ventral thoracic ribs; they are parallel to the latter in position and are imbedded in cartilage. The last pair of abdominal ribs is larger than the rest.

STERNUM

The anterior portion of the sternal apparatus consists of the completely ossified median interclavicle; the cartilaginous mass which connects this structure with the coracoids; the median sternal cartilage or imperfectly ossified bone to which the ventral thoracic ribs are attached; and the abdominal cartilage, which lodges the ossified abdominal ribs and which is connected with, and wedges between, the pubes.

PECTORAL GIRDLE AND FORE LIMB

SCAPULA.—The scapula is expanded near its summit into a broad, flat blade. Its shaft is thick and strong. The inferior end is expanded in several directions; half of the glenoid surface, which articulates with the humerus, is situated on the inferior corner of the postero-external portion of the scapula; at this point the latter is very thick. Above the glenoid surface is a roughened area of muscle attachment, which is situated on an oblique ridge near the posterior edge of the bone. The inferior portion of the anterior edge is elevated into a roughened ridge immediately below the shaft; near the antero-inferior corner of the bone this ridge dies out. Between this ridge and the process on which the glenoid surface is situated is a concave surface, which lodges a large mass of muscle. The surface which articulates with the coracoid is very broad near its posterior end, both scapula and coracoid being thick at that point to resist the thrust of the humerus; toward its anterior end this surface becomes narrower.

The inferior edge of the bone makes a very oblique angle with the longitudinal axis of the bone. The scapula extends somewhat backward as well as upward and inward over the ribs. The entire external surface is slightly convex; the internal surface is strongly concave. The superior portion of the bone makes a distinct angle with the inferior portion.

The scapula is considerably shorter than the humerus and femur, slightly shorter than the tibia, slightly longer than the fibula, ischium, and coracoid, and considerably longer than the radius, ulna, ilium, and pubis.

Measurements of Right Scapula (Amer. Mus. No. 7139)

Length, Total	22.0cm.
Antero-posterior Diameter of Superior Border	8.30
Antero-posterior Diameter of Inferior Border	8.90
Maximum Thickness of Distal End	3.40

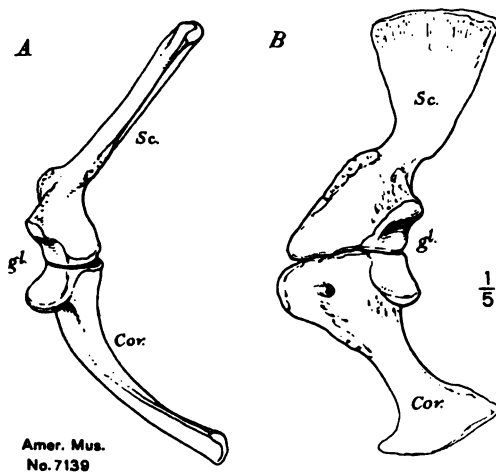
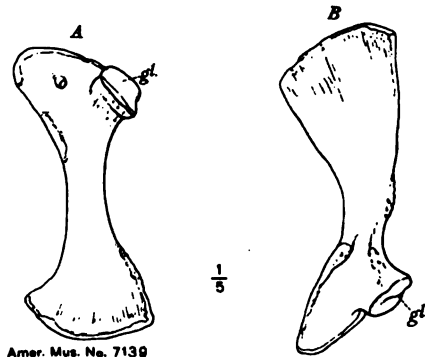


Fig. 11. Scapula and coracoid of *Crocodilus americanus*. Amer. Mus. No. 7139. One-fifth natural size. A, posterior view; B, external view. Cor., coracoid; gl., glenoid surface; Sc., scapula.

CORACOID.—The coracoid resembles the scapula in form in many respects; this resemblance is in many characters a symmetrical rather than a direct one. The surface of the coracoid which articulates with the scapula corresponds in outline with the corresponding surface of the latter bone. The external border of this surface makes an oblique angle with the longitudinal axis of the bone. The coracoid therefore extends obliquely backward, as well as downward and inward around the ventral surface of the thorax. The glenoid surface faces downward and outward. It is situated on a process which is sharply set off from the main mass of the bone. The entire superior surface of the bone is thick; its antero-posterior diameter is slightly greater than the same diameter of the inferior end of the scapula. The shaft is thick. The inferior end is ex-

panded antero-posteriorly and flattened laterally, but not to the same degree as in the scapula. The anterior part of the inferior expansion is considerably greater than the posterior part. The external surface is strongly convex and the internal surface is strongly concave. The coracoid foramen is large and conspicuous. It extends obliquely inward and backward from the external surface; on this surface it opens at a point about one-third of the distance back from the anterior border to the posterior border, while on the internal surface it opens at a point about two-fifths of the total distance back from the anterior border.

The coracoid is considerably shorter than the humerus and femur, slightly shorter than the scapula, ischium, tibia, and fibula, slightly longer than the pubis, and considerably longer than the radius, ulna and ilium.



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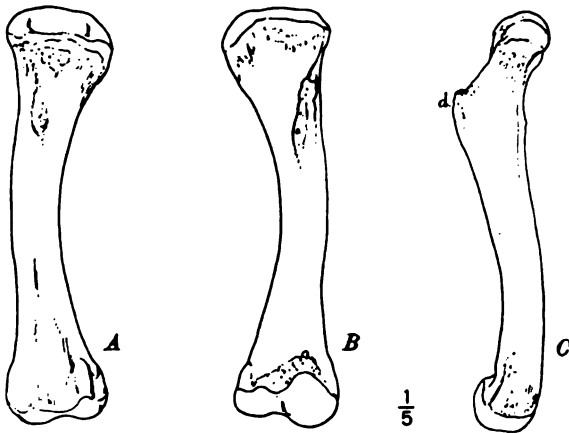
Fig. 12. Left scapula and coracoid of *Crocodilus americanus*. Amer. Mus. No. 7139. One-fifth natural size. External views. A, coracoid; B, scapula. gl., glenoid surface.

Measurements of Right Coracoid (Amer. Mus. No. 7139)

Length, Total	19.9cm.
Antero-posterior Diameter of Superior Surface	8.4
Antero-posterior Diameter of Inferior Surface	8.3
Maximum Thickness of Superior Surface	3.7

HUMERUS.—The humerus is moderately stout in proportion to its length. It is expanded at both proximal and distal ends; the planes of the proximal and distal expansions are practically parallel. The articular surfaces are distinctly marked; the articular surface of the proximal end faces upward and slightly backward; that of the distal end faces downward and slightly forward. In correlation with this the proximal

end of the bone curves slightly backward and the distal end curves slightly forward. The anterior and posterior surfaces of the bone immediately below the proximal articular surface and the anterior surface above the distal articular surface are greatly roughened, evidently in connection with the attachment of strong ligaments. The proximal articular surface is broad laterally and narrow antero-posteriorly; its anterior and posterior borders are nearly parallel, except near the internal margin, where the bone thickens; at the internal margin itself the bone is narrow. The distal articular surface is divided into two distinct condyles.



Amer. Mus. No. 7139

Fig. 13. Left humerus of *Crocodilus americanus*. Amer. Mus. No. 7139. One-fifth natural size. A, posterior view; B, anterior view; C, lateral view. d., deltoid crest.

When viewed from either the anterior or the posterior direction, the external border of the humerus is seen to be slightly convex and the internal border slightly concave. There is, thus, a certain amount of lateral curvature in the bone. On the posterior surface, about one-fourth of the total length of the bone below the proximal end is a small, elongate rugose area, which serves for muscle attachment. The lower portion of the distal articular surface, between the two condyles, is somewhat grooved.

The deltoid crest is large and prominent. It is near the proximal end of the bone. It is supported superiorly by a thin, sharp-edged process, but inferiorly it merges into the stout shaft of the bone. It rolls forward and inward strongly, and partially encloses a deep concavity on

the anterior surface of the bone for lodgment of muscles. Prominent rugosities are situated on the superior shoulder and inner surface of the process; its outer surface is smooth.

The humerus is considerably shorter than the femur; it is considerably longer than all the other limb and girdle bones.

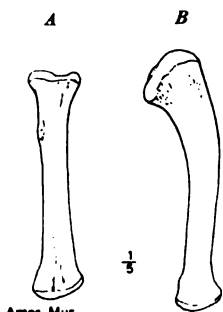
Measurements of Right Humerus (Amer. Mus. No. 7139)

Length, Total	16.8cm.
Breadth of Proximal End	7.1
Breadth of Distal End	6.7
Circumference of Shaft	6.9
Index of Circumference over Length	.410

RADIUS.—The radius is a relatively small bone. It is much shorter than the ulna, besides being more slender. It is expanded at both proximal and distal ends. The distal expansion is fore and aft only; the proximal expansion is both fore and aft and lateral. The shaft is elliptical in cross-section. The ulnar articular surfaces are distinct. Near the distal end, on both the ulnar and the free surface, is a low ridge. The radius is shorter than all the other limb and girdle bones.

Measurements of Left Radius (Amer. Mus. No. 7139)

A	B	Length, Total	14.9cm.
		Maximum Diameter, Proximal End	3.4
		Maximum Diameter, Distal End	3.1



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Fig. 14. Left radius and ulna of *Crocodilus americanus*. Amer. Mus. No. 7139. One-fifth natural size. A, anterior view of radius; B, lateral view of ulna.

ULNA.—The ulna is characteristic in form. It is very thick at its proximal end and small at its distal end. Its distal end is compressed laterally, so that its antero-posterior diameter is considerably greater than its transverse. The shaft is somewhat flattened and is decidedly curved. The large proximal articular surface faces forward as well as upward; the distal articular surface faces slightly inward as well as downward. On the internal surface of the bone, at the distal end, are situated two small oblique processes. The posterior border of the ulna is strongly convex and the anterior border is strongly concave.

The ulna is shorter than the scapula, coracoid, humerus, pubis, ischium, femur, tibia, and fibula; it is equal in length to the ilium, and is longer than the radius.

Measurements of Right Ulna (Amer. Mus. No. 7139)

Length, Total	17.2cm.
Antero-posterior Diameter of Proximal End	4.3
Antero-posterior Diameter of Distal End	3.1

CARPUS.—The proximal row of carpals consists of three bones; these are the radiale, ulnare, and pisiform. The distal row consists of one bone only. The radiale is much larger than the ulnare. Its greater length is correlated with the shortness of the radius; the length of radius plus radiale is approximately equal to that of ulna plus ulnare. Both radiale and ulnare are long in proportion to their breadth; and both are expanded at their ends like limb bones. The pisiform is very small.

The carpi of Amer. Mus. No. 7139 are incomplete. Measurements and ratios are given for several other specimens.

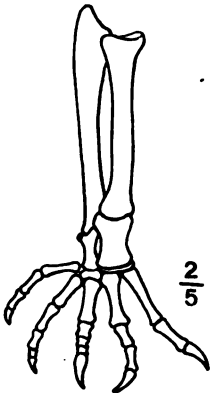


Fig. 15. Right radius, ulna, carpus, and manus of *Caiman sclerops*. Adapted from Brühl's figure. Two-fifths natural size. Anterior view.

Measurements and Ratios

Specimen No.	Length, Left Radiale	Length, Left Ulnare	Length, Left Radiale	Length, Left Ulnare	Length, Left Radiale	Length, Left Ulnare
			Length, Left Radius	Length, Left Ulna	Length, Left Mtc. III	Length, Left Mtc. III
Mus. Comp. Zool. No. 4043 (<i>Caiman niger</i>)	2.5cm.	1.5cm.	.274	.141	.694	.416
Mus. Comp. Zool. No. 5082 (<i>Caiman sclerops</i>)	1.0	.58	.262	.126	.666	.386
Amer. Mus. No. 15182 (<i>Crocodilus americanus</i>)	1.4	.80	.274	.140	.777	.444

MANUS.—The five digits in the manus are all well-developed. The phalangeal formula is 2, 3, 4, 4, 3. The second and third digits are longer than the first, fourth, and fifth. The second metacarpal is the longest; the third metacarpal is second in length; the first metacarpal is third in length; the fourth metacarpal is fourth in length; and the fifth metacarpal is the shortest. The manus is shorter than the pes and is relatively broader in proportion to its length.

Measurements

Specimen No.	Length, Left Mtc. I	Length, Left Mtc. II	Length, Left Mtc. III	Length, Left Mtc. IV	Length, Left Mtc. V
Mus. Comp. Zool. No. 4043 (<i>Caiman niger</i>)	3.08cm.	3.8cm.	3.60cm.	2.75cm.	1.53cm.
Mus. Comp. Zool. No. 5082 (<i>Caiman sclerops</i>)	1.30	1.50	1.40	1.10	.075
Amer. Mus. No. 15182 (<i>Crocodilus americanus</i>)	1.40	1.73	1.80	1.52	1.08

Specimen No.	Length, Left Digit I	Length, Left Digit II	Length, Left Digit III	Length, Left Digit IV	Length, Left Digit V
Mus. Comp. Zool. No. 5082 (<i>Caiman sclerops</i>)	2.73cm.	3.41cm.	3.42cm.	2.47cm.	1.87cm.

Ratios

Specimen No.	Length, Right Mtc. III	Length, Right Mtc. III	Length, Right Mtc. III
	Length, Right Humerus	Length, Right Radius	Length, Right Ulna
Mus. Comp. Zool. No. 4043 (<i>Caiman niger</i>)	.241	.395	.339
Mus. Comp. Zool. No. 5082 (<i>Caiman sclerops</i>)	.238	.337	.305
Amer. Mus. No. 15182 (<i>Crocodilus americanus</i>)	.224	.340	.302

PELVIC GIRDLE AND HIND LIMB

ILIUM.—The ilium is very irregular in outline. It is produced backward into a conspicuous posterior process; at its anterior end it does not extend forward beyond the anterior process which articulates with the ischium. The superior border is very irregular, especially near the anterior end, where it is broken into two distinct portions by a sharp process which extends upward and forward; the superior border is very rugose. The external surface of the ilium is deeply concave between the two processes which articulate with the ischium; this concave portion constitutes a closed acetabulum. The external surface of the posterior process is smooth. The ilium has two distinct articulations with the ischium and none with the pubis directly; both of the ischiadic surfaces

are situated on stout processes. The anterior ischiadic surface is rather smoothly rounded; the posterior one is more nearly flat, but is also strongly rugose. The two articular processes are separated inferiorly by a thin wall of bone.

The superior portion of the internal surface of the ilium is smooth. The greater portion of the internal surface of the posterior process is contained in this smooth area. The inferior portion of the internal surface is occupied by the exceedingly rugose areas which articulate with the sacral vertebrae. These areas are separated from each other by a prominent vertical ridge. They are very irregularly shaped and are excavated into deep concavities and elevated into processes and ridges, all of which are greatly roughened. The anterior of the two articular surfaces is short in the antero-posterior direction; the posterior surface extends back on the posterior process. A smooth triangular area is situated partly between and partly below the articular surfaces.

The ilium is considerably shorter than the scapula, coracoid, humerus, ischium, femur, tibia, and fibula; slightly shorter than the pubis; about equal in length to the ulna; and slightly longer than the radius.



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Fig. 16. Left ilium of *Crocodilus americanus*. Amer. Mus. No. 7139. One-fifth natural size. External view.

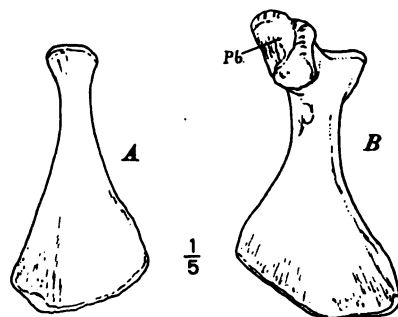
Measurements of Right Ilium (Amer. Mus. No. 7139)

Length, Total, Oblique	17.1cm.
Length, Total, Antero-posterior	15.3
Distance Across Both Ischiadic Processes	10.7

ISCHIUM.—The ischium is a large bone, much larger than the pubis. In outline it is complex. It articulates with the ilium at two distinct points. The anterior of the iliac articulations is situated on a distinct process, which excludes the pubis from contact with the ilium. The inferior surface of the anterior iliac process is partly rugose, where muscles or ligaments attach, and smooth where the bone articulates with the pubis. The posterior articulation with the ilium is situated at the head of the bone, above the shaft. Between the two iliac articular surfaces the superior surface of the ischium forms an infra-acetabular boundary. The superior portion of the shaft is roughly semicircular in cross-section. Between this portion of the shaft and the head a conspicuous foramen enters the bone; it does not completely pierce it, however.

The distal portion of the shaft is greatly expanded; the maximum diameter of this expansion is oblique in position. The entire external surface of the ischium is somewhat convex and the internal surface concave. The two ischia do not articulate with each other distally.

The ischium is considerably shorter than the humerus and femur; slightly shorter than the scapula, tibia, and fibula; slightly longer than the coracoid and pubis; and considerably longer than the radius, ulna, and ilium.



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Fig. 17. Left pubis and ischium of *Crocodilus americanus*. Amer. Mus. No. 7139. One-fifth natural size. A, external view of pubis; B, external view of ischium. Pb., pubic surface of ischium.

Measurements of Right Ischium (Amer. Mus. No. 7139)

Maximum Length, Oblique	17.5cm.
Antero-posterior, Diameter, Proximal End	3.1
Maximum Diameter Distal End	8.8

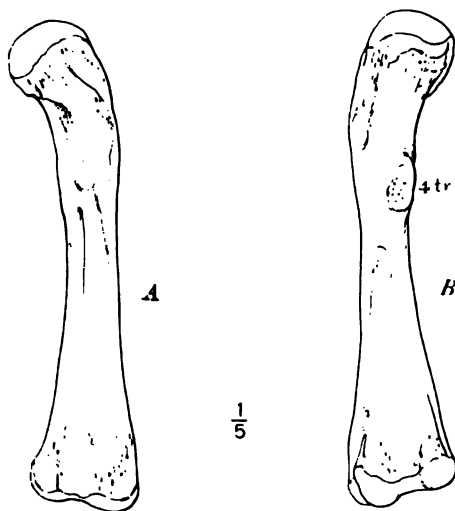
PUBIS.—The crocodilian pubis is a characteristic bone. It is roughly triangular in outline, the relatively narrow base of the triangle being at the distal end. The surface which articulates with the ischium is moderately smooth and is subcircular in outline; it is situated on the expanded proximal end of the bone. The shaft of the bone, immediately below the proximal process, is subcylindrical in form. Distally the shaft becomes thinner in the lateral direction and increased in antero-posterior diameter, merging into the flattened distal end. The external surface of the bone is gently convex, and the internal surface gently concave. The bone articulates with its fellow at the median line along a thin edge.

The pubis is considerably shorter than all the other limb and girdle bones except the radius, ulna, and ilium, which it exceeds in length.

Measurements of Right Pubis (Amer. Mus. No. 7139)

Length, Total	17.5cm.
Maximum Diameter, Proximal End	3.1
Minimum Diameter, Proximal End	2.7
Breadth, Distal End	8.7

FEMUR.—The femur is by far the longest of the crocodilian limb bones. It is expanded at both proximal and distal ends. The planes of the proximal and distal expansions are not parallel, as in the humerus, but oblique to each other. The articular surface of the head is large and round. The antero-internal border near the proximal end is convex and



Mus. No. 7139

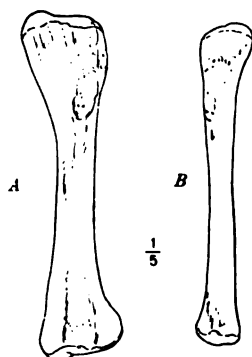
Fig. 18. Left femur of *Crocodilus americanus*. Amer. Mus. No. 7139. One-fifth natural size. A, posterior view; B, anterior view; 4 tr., fourth trochanter.

the postero-external border is concave. The anterior surface is very rough near the proximal end. The posterior surface, above the fourth trochanter, is concave. The fourth trochanter is large and prominent; it is much nearer the proximal than the distal end. On it, and also internal to it, are deep rugosities. The shaft is nearly circular. The bone is curved near the distal end, so that the condyles are oblique in position with reference to the shaft; the external surface, near the distal end, is convex and the internal surface is concave. Both external and internal surfaces are grooved and rugose.

Measurements of Right Femur (Amer. Mus. No. 7139)

Length, Total	32.5cm.
Breadth, Proximal End	6.8
Breadth, Distal End	7.05
Circumference of Shaft	11.0
Distance from Center of Fourth Trochanter to Proximal End	11.55
Distance from Center of Fourth Trochanter to Distal End	20.95
Index	.338
Ratio, $\frac{\text{Center of 4th Trochanter-Proximal End}}{\text{Center of 4th Trochanter-Distal End}}$	.551

TIBIA.—The tibia is a stout, massive bone. Its proximal end is especially strong. The proximal surface is characteristic. It is triangular in outline, with the apex of the triangle directed forward; it is also slightly



Amer. Mus. No. 7139

Fig. 19. Tibia and fibula of *Crocodilus americanus*. Amer. Mus. No. 7139. One-fifth natural size. A, anterior view of tibia; B, lateral view of fibula.

ly concave. The proximal portion of the shaft is stout and is triangular in outline; on its anterior margin it is compressed into a ridge; the ridge carries a conspicuous rugosity. The central portion of the shaft is much more slender than the proximal end; its anterior horizontal profile is semicircular; it is compressed into a low ridge posteriorly, so that the posterior horizontal profile is not semicircular. The distal portion of the shaft is expanded in the direction of the distal end of the bone. At its distal end the tibia is expanded in an oblique antero-external postero-internal direction and flattened in a direction perpendicular to this. The distal surface is obliquely truncated, the bone being longer at the postero-internal angle of the distal end than at antero-external angle.

The distal surface rolls backward somewhat, in the posterior direction. Near its central portion, on the postero-external surface, is a small, but conspicuous, concavity, which lodges the distal portion of the fibula.

The tibia is considerably shorter than the humerus and the femur; slightly longer than the scapula, coracoid, ischium and fibula; and considerably longer than the radius, ulna, ilium, and pubis.

Measurements of Right Tibia (Amer. Mus. No. 7139)

Length, Total	22.7 cm.
Maximum Diameter, Proximal End	5.0
Maximum Diameter, Distal End	5.1

FIBULA.—The crocodilian fibula is long and slender. At the proximal end it is expanded and at the same time flattened. The inner surface, near the proximal end, has a smooth surface for articulation with the tibia; below this surface is a rugosity. On the external surface of the shaft, about one-fifth of the total length of the bone below the proximal extremity, is a conspicuous muscle rugosity. The central portion of the shaft is cylindrical in cross-section. The distal extremity is expanded, but is not flattened at the proximal end. The plane of maximum expansion at the distal end is oblique to the plane of maximum expansion at the proximal end. A distinct process at the distal end articulates with a grooved surface on the tibia.

The fibula is considerably shorter than the humerus and femur; slightly shorter than the scapula, ischium, and tibia; slightly longer than the coracoid, ilium, and pubis; and considerably longer than the radius and ulna.

Measurements of Right Fibula (Amer. Mus. No. 7139)

Length, Total	21.1cm.
Maximum Diameter, Proximal End	3.35
Maximum Diameter, Distal End	3.10
Circumference of Shaft	5.20
Index $\frac{\text{Circ. Shaft}}{\text{Total Length}}$	.246

TARSUS.—The proximal row of tarsal bones consists of a large, irregular tibiale, or astragalus, and a prominent fibulare, or calcaneum. The distal row consists of three bones. The tibiale is of moderate size; besides its articulation with the tibia this bone has contacts with the fibula, fibulare, the innermost of the distal tarsals, and Metatarsal I. The fibulare extends backward with a shaft and an expanded distal end. It forms contacts with the fibula, tibiale, and the inner of the three distal tarsal bones. The innermost distal tarsal lies external to the proximal end of Metatarsal I, above Metatarsal II, and partly above Metatarsal III. The middle



Fig. 20. Right tibia, fibula, tarsus, and pes of *Caiman sclerops*. Adapted from Brühl's figure. Two-fifths natural size. Anterior view.

distal tarsal lies above the third and fourth metatarsals. The external distal tarsal has a very slight contact with the fourth metatarsal. It extends backward as a free process.

Measurements and Ratios

Specimen No.	Maximum diameter, Left Tibiale	Length, Left Fibulare	Max. Diam. Left Tibiale	Length, Left Fibulare	Max. Diam. Left Tibiale	Length, Left Fibulare
			Length, Left Tibia	Length, Left Fibula	Length, Left Mtt. II	Length, Left Mtt. III
Mus. Comp. Zool. No. 4043 (<i>Caiman niger</i>)	3.2cm. e.	4.0cm.	.217	.289	.326	.308
Mus. Comp. Zool. No. 5082 (<i>Caiman sclerops</i>)	1.3	1.52	.222	.259	.372	.416
Amer. Mus. Mo. 15182 (<i>Crocodylus americanus</i>)	1.45(est.)	2.00	.210	.298	.329	.454

PES.—The pes consists of four digits only. It is much longer than manus. The phalangeal formula is 2, 3, 4, 4. The first digit is somewhat stouter than the others. The third digit is the longest; the second digit is second in length; the fourth digit is third in length; and the first digit is the shortest. The metatarsals are relatively long compared with the phalanges. The digits all support claws and are pressed closely together.

Measurements and Ratios

Specimen No.	Length, Mtt. I	Length, Mtt. II	Length, Mtt. III	Length, Mtt. IV	Length, Mtt. II	Length, Left Mtt. II	Length, Left Mtt. II
					Length, Left Femur	Length, Left Tibia	Length, Left Fibula
Mus. Comp. Zool. No. 4043 (<i>Caiman niger</i>)	8.7cm.	9.7cm.	9.2cm.	8.1cm.	.510	.638	.413
Mus. Comp. Zool. No. 5082 (<i>Caiman sclerops</i>)	3.2	3.7	3.6	3.2	.510	.649	.654
Amer. Mus. No. 15182 (<i>Crocodylus americanus</i>)	4.0	4.3	4.25	3.9	.477	.623	.641

RATIOS OF LIMB AND GIRDLE BONES OF *CROCODYLUS AMERICANUS*
(Amer. Mus. No. 7139)

<u>Length Coracoid</u>	.904	<u>Length Coracoid</u>	.938
<u>Length Scapula</u>		<u>Length Fibula</u>	
<u>Length Scapula</u>	.814	<u>Length Radius</u>	.550
<u>Length Humerus</u>		<u>Length Humerus</u>	
<u>Length Radius</u>	.677	<u>Length Ulna</u>	.629
<u>Length Scapula</u>		<u>Length Humerus</u>	
<u>Length Ulna</u>	.772	<u>Length Ilium</u>	.633
<u>Length Scapula</u>		<u>Length Humerus</u>	
<u>Length Ilium</u>	.777	<u>Length Ischium</u>	.688
<u>Length Scapula</u>		<u>Length Humerus</u>	
<u>Length Ischium</u>	.845	<u>Length Pubis</u>	.648
<u>Length Scapula</u>		<u>Length Humerus</u>	
<u>Length Pubis</u>	.795	<u>Length Humerus</u>	.830
<u>Length Scapula</u>		<u>Length Femur</u>	
<u>Length Scapula</u>	.676	<u>Length Tibia</u>	.844
<u>Length Femur</u>		<u>Length Humerus</u>	
<u>Length Tibia</u>	.964	<u>Length Fibula</u>	.785
<u>Length Scapula</u>		<u>Length Humerus</u>	
<u>Length Fibula</u>	.963	<u>Length Ulna</u>	.994
<u>Length Scapula</u>		<u>Length Ilium</u>	
<u>Length Coracoid</u>	.737	<u>Length Ulna</u>	.913
<u>Length Humerus</u>		<u>Length Ischium</u>	
<u>Length Radius</u>	.748	<u>Length Ulna</u>	.971
<u>Length Coracoid</u>		<u>Length Pubis</u>	
<u>Length Ulna</u>	.854	<u>Length Ulna</u>	.523
<u>Length Coracoid</u>		<u>Length Femur</u>	
<u>Length Ilium</u>	.859	<u>Length Ulna</u>	.745
<u>Length Coracoid</u>		<u>Length Tibia</u>	
<u>Length Pubis</u>	.879	<u>Length Ulna</u>	.801
<u>Length Coracoid</u>		<u>Length Fibula</u>	
<u>Length Ischium</u>	.934	<u>Length Radius</u>	.876
<u>Length Coracoid</u>		<u>Length Ulna</u>	
<u>Length Coracoid</u>	.612	<u>Length Pubis</u>	.871
<u>Length Femur</u>		<u>Length Ilium</u>	
<u>Length Coracoid</u>	.872		
<u>Length Tibia</u>			

<u>Length Radius</u>	.801	<u>Length Pubis</u>	.940
<u>Length Ischium</u>		<u>Length Ischium</u>	
<u>Length Radius</u>	.851	<u>Length Ischium</u>	.580
<u>Length Pubis</u>		<u>Length Femur</u>	
<u>Length Radius</u>	.458	<u>Length Ischium</u>	.815
<u>Length Femur</u>		<u>Length Tibia</u>	
<u>Length Radius</u>	.653	<u>Length Ischium</u>	.877
<u>Length Tibia</u>		<u>Length Fibula</u>	
<u>Length Radius</u>	.702	<u>Length Pubis</u>	.538
<u>Length Fibula</u>		<u>Length Femur</u>	
<u>Length Ilium</u>	.919	<u>Length Pubis</u>	.767
<u>Length Ischium</u>		<u>Length Tibia</u>	
<u>Length Ilium</u>	.977	<u>Length Pubis</u>	.825
<u>Length Pubis</u>		<u>Length Fibula</u>	
<u>Length Ilium</u>	.526	<u>Length Tibia</u>	.701
<u>Length Femur</u>		<u>Length Femur</u>	
<u>Length Ilium</u>	.754	<u>Length Fibula</u>	.652
<u>Length Tibia</u>		<u>Length Femur</u>	
<u>Length Ilium</u>	.806	<u>Length Fibula</u>	.929
<u>Length Fibula</u>		<u>Length Tibia</u>	

PLATE XIII

PLATE XIII

Dorsal vertebræ of *Crocodilus americanus*

Amer. Mus. No. 7139

One-fifth natural size

A.—Anterior views

B.—Lateral views, left side

C.—Posterior views

1-13.—First to thirteenth dorsal vertebræ, inclusive

Di., diapophysis; N. C., neural canal; Pa., parapophysis; Poz., p
physis; Prz., presygapophysis; Sp., spine.

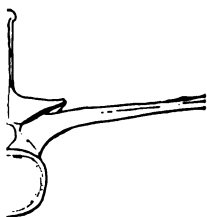
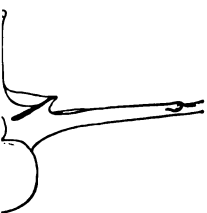


PLATE XIV

PLATE XIV

Caudal vertebræ of *Crococilus americanus*

Amer. Mus. No. 7139

One-fifth natural size

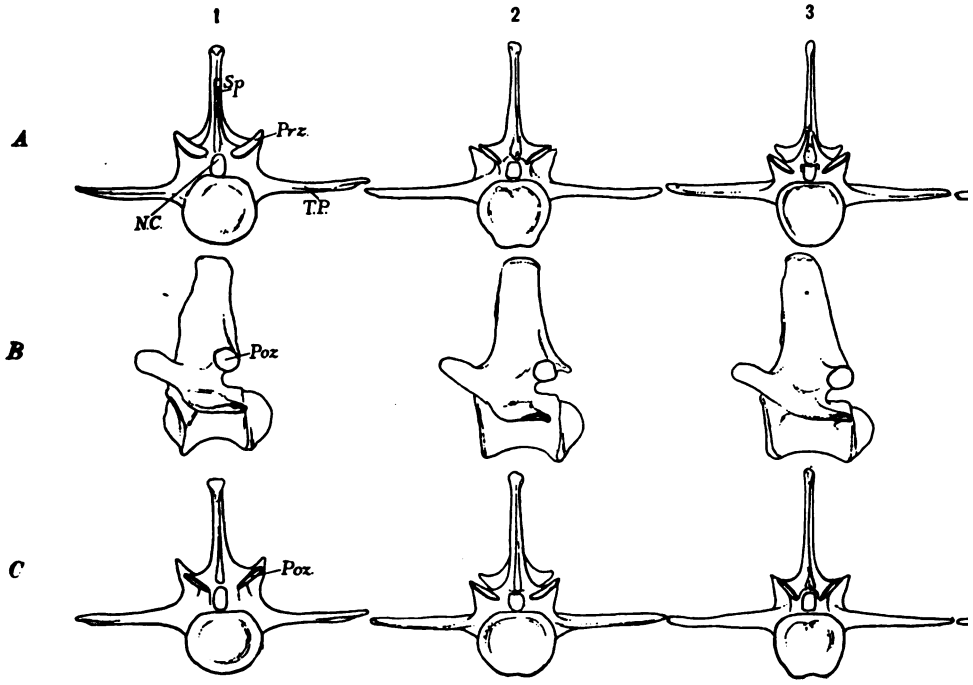
A.—Anterior views

B.—Lateral views, left side

C.—Posterior views

1-37. First to thirty-seventh caudal vertebræ, inclusive

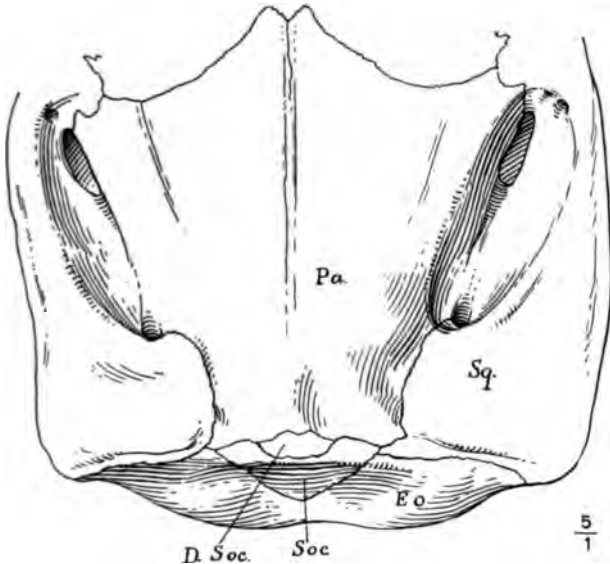
N. C., neural canal; Poz., postzygapophysis; Prz., prezygapophysis; Sp., spine; T. P., transverse process.



Article IX.—THE DERMO-SUPRAOCCIPITAL BONE IN THE CROCODILIA¹

BY CHARLES C. MOOK

In a number of figures of Permian reptiles Williston has indicated dermo-supraoccipital bones, lying immediately posterior to the parietals. These dermo-supraoccipital bones are large and prominent in three of the Permian genera, i. e., *Limnoscelis*, *Seymouria*, and *Nothodon*. All of the bones of the surface of the cranium are paired in these genera.



Mus. Comp. Zool. No. 13101

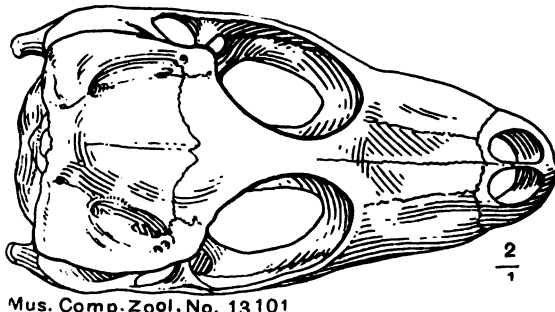
Fig. 1. Posterior portion of brain-case of a very young alligator (*Alligator mississippiensis*) Mus. Comp. Zool. No. 13101. Five times natural size. Superior view. D. Soc., dermo-supraoccipital; Eo., exoccipital; Pa., parietal; Soc., supraoccipital; Sq., squamosal.

Of *Nothodon* Williston says: "Back of the parietals are the broad dermo-occipitals, which are blended on the upper side with the supraoccipitals almost indistinguishably. I believe, however, that their sutural separation follows about the line as I have drawn it." He describes the inferior surface in detail.

¹Contributions to the Osteology, Affinities, and Distribution of the Crocodilia. No. 6.

Miall has noted the dermo-supraoccipital as a component of the skull of the Crocodilia. It has never been figured in this group and does not appear on most crocodile skulls.

Upon taking up the study of the Crocodilia it was suggested to the writer by Professor W. K. Gregory that it would be advisable to make a careful study of very young crocodilian skulls to verify Miall's statement, if possible, and to determine the characters of the dermo-supraoccipital if it were found to be present. Two very young alligator skulls (Amer. Mus. No. 2320 and Amer. Mus. No. 2321), which are 57 mm. and 53 mm. long, respectively, were examined for this purpose and showed no indications of the dermo-supraoccipital as a separate element. In a very young skull in the collection of the Museum of Comparative Zoology kindly loaned by Dr. Thomas Barbour (Mus. Comp. Zool. No. 13101), which is only 35.3 mm. long, a distinct bone is visible posterior to the parietal and anterior to the supraoccipital in position; this bone is united to the parietal and supraoccipital by distinct sutures. In a slightly larger specimen (Mus. Comp. Zool. No. 13102), which is 39.5 mm. long, the element is likewise clearly visible but, while its suture with the supraoccipital is clean-cut and open, its suture with the parietal is obscure; the bone appears to be partially fused with the parietal.



Mus. Comp. Zool. No. 13101

Fig. 2. Skull of young alligator (*Alligator mississippiensis*). Mus. Comp. Zool. No. 13101. Twice natural size. Superior view. In this figure the relations of the parts represented in Fig. 1 are indicated.

Regarding the element noted, the following may be said: it occupies the position indicated by Williston for the dermo-supraoccipital in *Limnoscelis*, *Nothodon*, and *Seymouria*; furthermore, it appears to be more closely connected with the parietal (of dermal origin) than with the supraoccipital (of cartilage origin). From these facts it may be confidently stated that the element is the dermo-supraoccipital and that it fuses at a very early stage with the parietal. Along with the other cranial

elements, it has lost its paired character. This fusion has been greatly accelerated, in comparison with the Permian reptiles, so the bone is only present as a distinct element in a very young stage.

The bone is much smaller than the supraoccipital and is bounded by it laterally as well as posteriorly. In respect to the latter character the bone differs from the corresponding element in the Permian reptiles, in which it is large and is bounded laterally by the tabulars and supratemporals, separating the parietal completely from the supraoccipital. In shape the bone is broader than it is long, its length being about two-fifths as great as its breadth. Its posterior boundary is a symmetrical convex curve; its anterior boundary is more complex but is symmetrical; it extends inward and slightly forward from each sharp lateral corner, then curves forward, and then backward to the median line and in a symmetrical direction to the opposite lateral corner. The bone is therefore slightly notched at the median line.

It will be interesting to search for this element in the Tertiary and Mesozoic crocodilians and to trace, if possible, its history back through a primitive diapsid stem to the ancestral Palæozoic Reptilia.

Article X.—*ALLOGNATHOSUCHUS*, A NEW GENUS OF
EOCENE CROCODYLIANS¹

BY CHARLES C. MOOK

PLATE XV

This genus is founded on *Crocodylus polyodon* Cope, which was originally described in 1873 in the 6th Annual Report of the U. S. Geological and Geographical Survey of the Territories, page 614. Cope's description of the species is as follows:

Represented by portions of cranium and teeth, with probably some vertebrae found close to them. This crocodile is similar in size to the *D. subulatus*, or our alligator. It differs much from the last in the arrangement of the teeth. There is one pre-eminently large canine opposite the symphysis, (in *D. subulatus* this tooth is opposite the posterior end of the same,) which is followed by nine very small teeth, whose round alveoli are only separated by very thin walls. Following the last of these immediately is another very large tooth, with nearly round alveolus, which is closely succeeded by other smaller teeth of larger size than those in front of it, and not differing in this respect among themselves. The crowns of the teeth are cylindric at base, and have a double ridge on the anterior outer aspect. The enamel is obsoletely rugose, striate at the base. The external surface of the dentary bone is deeply and coarsely pitted; at its anterior part the pits are close, deep, and small; on the inferior face they are deep, short grooves. There is a series of close, small foramina along the inner side of the alveolæ.

Measurements

	M.
Depth of symphysis	0.014
Diameter "anterior end of canine tooth"	.006
Distance of same from median "canine"	.020
Depth dentary bone at latter	.027
Width ramus at anterior canine	.025

This species differs in many respects from the one last described, (*subulatus*). The teeth, anteriorly, are much more closely placed, and the anterior and middle canines are less separated, and more numerous small teeth occupy the interval. The splenial bone has a larger share in the symphysis, and the symphysis is much more profound. The teeth are not fluted.

The type specimen was found on the bluffs of Upper Green River by the writer.

The species was redescribed and partially figured in 1884 in the volume on the Tertiary Vertebrata.²

¹Contributions to the Osteology, Affinities, and Distribution of the Crocodilia, p. 7.

²Report U. S. Geological and Geographical Survey of the Territories, Vol. 152, Tertiary Vertebrata, by E. D. Cope, p. 154, Pl. xxxi, fig. 2, 3.

The type specimen, which now constitutes U. S. National Museum No. 4112, was kindly loaned to the writer for study and description through the courtesy of Mr. C. W. Gilmore. The geological horizon is Lower Bridger.

Upon studying the type, the writer noted that it differed from all other known crocodilian jaws (except the jaw of *Crocodylus heterodon*, described below) to a considerable degree, also that Cope's description is only partially accurate and does not do justice to the peculiar character of the specimen.

DESCRIPTION OF TYPE OF *Allognathosuchus polyodon*

TYPE MATERIAL.—The type specimen consists of the greater portion of a left mandibular ramus. The teeth are preserved only as a few fragments, but many of the alveoli are complete. The anterior end of the jaw is lacking and the region of the mandibular foramen is incomplete. Part of the inner portion of the jaw is missing, and no part of the splenial bone is preserved, but its impress upon the dentary is marked.

GENERAL FORM.—The general form of this jaw is as unusual as its apparent dentition. The jaw, as a whole, is slender; it is more curved in the vertical plane than in most crocodilians, the inferior border being decidedly convex and the superior border generally, though irregularly, concave.

The anterior, or symphysial, portion is shallow vertically and moderately wide. The chief external surface at this point faces obliquely downward and outward, but principally downward. The angle of the symphysial surface with the longitudinal axis of the ramus indicates that the two rami did not diverge sharply and that the entire jaw, and consequently the skull also, was narrow. The splenial bone evidently formed a part of the symphysis. The anterior end of the jaw is elevated, and immediately posterior to this the superior border descends in a gentle curve and, slightly posterior to the level of the posterior end of the symphysis, rises again in a reverse curve to a prominent process which lodges the large teeth described below. At this point the external surface is divided into two portions, one being chiefly external and the other largely ventral; the two portions are sharply separated from each other.

Posterior to the superior process noted above the superior border again descends in a gentle but pronounced curve and, very slightly anterior to what appears to be the posterior end of the dental series, rises again slightly. At the apparent posterior end of the dental series the border rises abruptly, so that its posterior, or surangular, portion is distinctly higher than its anterior, or dental, portion.

The series of curves in the anterior portion of the superior border gives the jaw a wavy appearance unlike any other known crocodilian. Very large and old specimens of some of the living species of crocodiles and alligators sometimes have the superior border of the jaw elevated in some places and depressed in others, but never to the extent in this fossil form; in the modern specimens it is always relatively slight in proportion to the length of the dental series.

The borders of the mandibular foramen are not preserved, but the foramen could not have been large. The posterior two-fifths of the jaw is deep vertically. The posterior process of the articular bone is deflected inward.

DENTITION.—None of the teeth are perfectly preserved, but in several of them the form is discernible. The alveoli indicate the size of the teeth. The anterior end of the jaw being missing, it is impossible to determine the number of teeth accurately. The first alveolus in the specimen is in the position usual for the third mandibular tooth, and may provisionally be regarded as such. This alveolus is of moderate size. Immediately posterior to the first alveolus is the second, which contains the broken base of a tooth. This alveolus is very large, having twice the diameter of the first.

Posterior to this large second alveolus are eight small alveoli, not nine as stated by Cope. The first of these is slightly smaller than the first alveolus in the jaw. From this the small alveoli diminish in size steadily to the sixth and then increase slightly to the eighth. The tooth itself is partly preserved in the eighth alveolus of this group; it is very small and is sharply pointed. These eight alveoli face obliquely outward as well as upward.

Posterior to this group of eight small alveoli is a large alveolus equaling in size the second in the jaw; posterior to it is a slightly smaller alveolus, containing the base of a stout conical tooth; these two alveoli occupy the summit of the elevation of the superior border of the jaw mentioned above. The second of the two alveoli, though smaller than the first, is considerably larger than any of the group of eight alveoli noted above. All of the alveoli described so far are separated from each other by thin walls of bone; the teeth were crowded close together.

Posterior to the two alveoli on the summit of the superior process of the dentary, just described, is a series of alveoli of moderate size, which were evidently confluent with each other. This cannot be determined accurately, as the inner wall is not preserved. Five of these alveoli are distinctly visible, and it is probable that another followed these in a space now occupied in the specimen by plaster.

The total number of alveoli clearly visible in the jaw is seventeen. Adding the hypothetical two anterior teeth (considering the first alveolus preserved as No. 3) and the hypothetical one last tooth, the probable number of teeth in the jaw is twenty. The correct number may have been one more or one or two less, hardly more than that.

The actual number observable, seventeen, is greater than in any known species of the genus *Crocodylus*, also the relative size and distribution of the teeth is different from any species of that genus. The symphysial surface extends back to a point opposite the third or fourth of the group of eight small alveoli.

SURFACE.—The anterior portion of the external surface is excavated by numerous small pits; on the ventral portion of the anterior end of the external surface the pits are elongate. On the upper portion of the lateral surface, especially on the side of the superior process of the dentary, the surface of the bone is smooth. The greater part of the external surface of the angular and surangular bones is sculptured by deep, irregular, coarse-textured pitting. The region posterior to this area of coarse pitting, on the angular and articular bones antero-inferior to the posterior process of the articular, is smooth.

Measurements

Total Length of Portion of Mandible Preserved	21.3cm.
Total Length of Portion of Dental Series	9.1
Antero-posterior Diameter of Second Alveolus	.9
Length of Row of Eight Small Alveoli	3.1
Antero-posterior Diameter of Eleventh Alveolus	.9
Depth of Symphysis	1.3
Breadth of Ramus at Posterior End of Symphysis	2.5
Height of Ramus at Bottom of First Concavity	1.4
Height of Ramus at Superior Process of Dentary	2.4
Maximum Height of Ramus in Angular-surangular Region	4.4

CONCLUSIONS.—The form of the jaw and the character of the dentition clearly indicate that this specimen did not belong to a species of the genus *Crocodylus*, although it is certainly referable to the *Crocodylia*. It is doubtful if it may be included in the family *Crocodylidae*. The solution of this problem may be deferred until further study of the Eocene *Crocodylia* has been made.

For the reasons outlined above the specimen is referred to a new genus, which may be called ***Allognathosuchus***, in allusion to the strange character of the mandible, with *Crocodylus polyodon* Cope as the type species, now becoming *Allognathosuchus polyodon*.

SUMMARY OF GENERIC CHARACTERS.—Dental series short in comparison with post-dental portion of jaw; prominent elevation or process on dentary bone; abrupt elevation from dental border to surangular border; teeth arranged in definite groups, sharply set off from each other in size; all teeth close together.

SUMMARY OF SPECIFIC CHARACTERS.—Two very large teeth, separated by eight small teeth facing obliquely outward as well as upward. Jaw relatively narrow.

Allognathosuchus heterodon (Cope)

In the collections of the American Museum are several short, broad crocodilian skulls in which the posterior teeth are flat and blunt, not pointed as are most crocodilian teeth; with these skulls are a number of fragmentary jaws and isolated teeth. All are from the Wasatch Beds.

These skulls and teeth agree with Cope's descriptions of *Crocodylus heterodon* and with the type of that species, which now constitutes U. S. National Museum No. 4115 and which is somewhat fragmentary in character; the skulls may be referred to that form. On comparing the jaws of these specimens with the type of *Allognathosuchus polyodon*, described above, a striking similarity was noted. The distribution of large and small teeth is similar in the Wasatch jaws to that of *A. polyodon*. The large superior process of the dentary, which is so prominent in the latter species, is also possessed by the Wasatch specimens. It therefore seems advisable to consider the Wasatch form generically identical with *A. polyodon*. Detailed characters of the form of the jaw and consequently of the skull, also of the teeth, differ from those of *A. polyodon*. The Wasatch form is therefore not identical specifically with *A. polyodon*. *Crocodylus heterodon* Cope therefore becomes *Allognathosuchus heterodon* (Cope). The skulls need further preparation before complete description may be attempted. The specific characters which they exhibit may be indicated here, however.

SUMMARY OF SPECIFIC CHARACTERS.—Skull and jaws very broad in proportion to their length. External narial aperture very broad. Seven or eight small teeth between two large teeth in anterior and middle parts of jaw. Posterior three teeth on either side in both upper and lower jaws flat and blunt, with the crowns lower than they are broad or long; in unworn teeth fine striations radiate outward from the center of the crown.

REMARKS

Allognathosuchus evidently represents a side line of crocodilians, differing from the normal Eusuchian type. It evidently did not survive Eocene time. The material discussed above is from Bridger and Wasatch beds, but in the collections of Puerco material in the American Museum are some small flat teeth closely resembling those of *A. heterodon*. It seems likely, therefore, that the genus existed in Paleocene as well as in Eocene time. The characters of the skull and jaws indicate an animal of somewhat different adaptations from the normal crocodilians.

PLATE XV

PLATE XV

Left Mandibular Ramus of *Allognathosuchus polyodon* (Cope)

Three-fourths natural size

U. S. Nat. Mus. No. 4112, type specimen

Upper Figure: Superior view

Lower Figure: Lateral view, left side



Article XI.—DESCRIPTION OF A SKULL OF A BRIDGER CROCODILIAN¹

BY CHARLES C. MOOK

PLATES XVI AND XVII

Among a number of well-preserved Tertiary crocodilian skulls in the American Museum collections is one which is unusually well preserved. This specimen (Amer. Mus. No. 6177) consists of a skull and jaws. The skull is complete except for the lack of a few teeth and the extremities of some delicate processes; it is very slightly distorted. The jaws are not so well preserved, the symphyseal portion being lacking. The specimen was collected in 1904 by Paul Miller at Henry's Fork Hill, in Horizon C4 of the Bridger Beds.

The identification of the skull is uncertain. It certainly belongs to a species of *Crocodylus*, but the present state of knowledge of the Eocene Crocodylia renders an accurate specific identification difficult, if not impossible. The characters of the skull agree very well with Marsh's description of *Crocodylus affinis*. There are several other Bridger species of *Crocodylus* described in the literature, based for the most part on fragmentary specimens. Until a careful comparison of the type specimens of these various species is made the specific identification of the Eocene crocodiles is uncertain. Provisionally the skull described is referred to *Crocodylus affinis* Marsh.

GENERAL FORM

In general form the skull is very short and broad. It is low vertically and relatively flat on its superior surface; this does not appear to be due to crushing.

The snout is slightly more than one and one-third times as long as it is broad at the base. The muzzle is narrow, being less than one-half as broad as the snout at its base. The constriction at the premaxillo-maxillary suture is deep; posterior to this the snout broadens considerably to the level of the fifth maxillary teeth; at the level of the seventh maxillary teeth the snout is very slightly constricted. The superior surface of the snout is very flat.

The interorbital region is very flat. The cranial table is moderately flat and is considerably broader than it is long. Its lateral borders converge very slightly forward. Its posterior border is very irregular.

¹Contributions to the Osteology, Affinities, and Distribution of the Crocodylia. No. 8.

THE CAVITIES OF THE SKULL

SUPRATEMPORAL FENESTRÆ.—The supratemporal fenestræ are moderately large. The fenestra of the right side is nearly circular, and that of the left side is elliptical in outline; this difference may be attributed to distortion. The interfenestral space is narrow.

INFRATEMPORAL FENESTRÆ.—These fenestræ are not especially characteristic, except that they face almost directly upward; they are scarcely visible when the skull is viewed from the side.

ORBITS.—These cavities are large and, like the infratemporal fenestræ, face almost directly upward. The space between them is of moderate breadth. The breadth of the orbits is great in proportion to their length.

EXTERNAL NARIAL APERTURE.—This cavity is about the same size as either of the supratemporal fenestræ, possibly being very slightly smaller. It is subquadrangular in outline; its anterior border is practically straight, and its lateral borders converge very slightly in the posterior direction. Vestiges of a median septum indicate that the aperture was at least partly divided.

PREMAXILLARY FORAMEN.—The premaxillary foramen is large. It is somewhat longer than broad, but is not slender. It is pointed at its anterior end and is broadly rounded on its lateral borders and its posterior end.

PALATINE FENESTRÆ.—These fenestræ are very large. They are somewhat irregular in outline. Their external and internal borders are both curved. The posterior end is broadly rounded; the anterior end is rounded, but more acutely. The fenestræ extend forward as far as the level of the ninth maxillary teeth.

INTERNAL NARIAL APERTURE.—This cavity is large; it faces directly downward. It is situated near, but not at the posterior ends of the pterygoid bones.

THE BONES OF THE SKULL

PREMAXILLARIES.—The premaxillaries are small. They occupy a considerably smaller area on the superior surface of the skull, compared with that occupied by the maxillaries, than in most crocodilians. The anterior mass of the bone is not sharply separated from the posterior process, but merges into it; this posterior process extends back as far as the level of the fourth maxillary teeth.

On the palate the suture between the premaxillaries and the maxillaries is very irregular. On each side it extends irregularly inward and backward as far as the level of the posterior edge of the first maxil-

lary tooth, then inward and forward as far as the level of the anterior end of the first maxillary tooth, then inward and backward to the median line, which it meets at the level of the anterior edge of the third maxillary tooth. From the median line it extends in reverse order to the "canine" notch. All parts of the suture are irregular.

The right premaxillary contains alveoli of four teeth, some of which are partially preserved; the left premaxillary contains alveoli of five teeth, of which No. 4 is well preserved. This tooth is stout and long; it extends a considerable distance below the dental border, and was evidently not fully imbedded in its alveolus when buried. The tooth which is lacking on the right side is the small No. 2. There are no small foramina in the premaxillaries caused by piercing of the upper jaw by the teeth of the lower, but there is a pair of large, deep pits, which evidently lodged the first mandibular teeth, anterior and exterior to the premaxillary foramen and posterior and internal to the first premaxillary teeth.

MAXILLARIES.—The maxillaries are large, especially in the transverse diameter. Their contacts with the nasals are unusually short, being only about 28 per cent of the total length of the bones themselves. The contacts with the lacrymals are somewhat complex; they extend backward a short distance from their anterior ends in the same direction as the maxillo-nasal sutures, then turn almost directly outward for a short distance, and then turn back in a direction similar to their anterior portions. The maxillo-jugal sutures are very irregular. They occupy very little space in the longitudinal direction, though their transverse component of length is considerable.

On the palate the sutural connection with the premaxillaries has been described. The median suture of the two maxillaries with each other is short. The suture with the two palatines is almost semicircular in outline; the anterior convexity does not extend forward to the level of the anterior ends of the palatine fenestræ; in this respect the skull differs from all modern crocodilian skulls except perhaps *Osteolemus* and *Osteoblepharon*. The sutures with the ectopterygoids lie opposite four maxillary teeth.

Each maxillary contains alveoli for fifteen teeth. Most of these are preserved. The teeth are all very stout; the anterior ones are somewhat curved; the posterior ones are more nearly conical. The teeth are all close together, the only notable spacing being between the sixth and seventh teeth and this is less than in most crocodilian skulls.

NASALS.—The nasals extend forward a considerable distance into the narial aperture. They broaden rapidly to the points of contact of

premaxillaries, maxillaries, and nasals, and then more gradually to their broadest portions, where maxillaries, nasals, and lacrymals meet. Posterior to this point they narrow rapidly and irregularly, ending in a very irregular, but generally transverse, suture with the frontal.

LACRYMALS.—The lacrymal bones are unusually broad. Their lateral borders are nearly parallel throughout most of their length; their anterior processes are narrow and sharp and are sharply separated off from the main mass of the bone. Their sutures with the nasals are short.

PREFRONTALS.—These bones are of moderate size. They are characterized by the shape of their boundaries, which consist of three curves on each side. The external contacts, with the lacrymals chiefly, extend forward and inward in a slightly curved direction, with the convexity of the curve inward; the internal contacts, with the frontal and nasals, extend forward and outward and meet the external boundaries with a sharp point at the anterior end of the bone. The convexity of the curve of the internal border is directed inward. The third boundary curves occupy portions of the anterior walls of the orbits, their convexities facing, of course, inward and forward.

FRONTAL.—The frontal is very flat. Its anterior process is broad, especially at its anterior end. It is not sharply set off from the posterior plate. No part of the frontal forms a portion of the borders of the supratemporal fenestræ.

POSTORBITALS.—These bones are relatively small. They comprise about one-third of the lateral borders of the supratemporal fenestræ. They occupy about three-fifths as much of the surface of the cranial table as the squamosals.

SQUAMOSALS.—The squamosals are comparatively small, owing to the large size of the supratemporal fenestræ. They are broad in proportion to their length, but not in proportion to the breadth of the skull; they occupy slightly more than three-fifths of the posterior border of the cranial table.

PARIETAL.—The parietal is unusually broad. It is narrow between the fenestræ, but expands rapidly anterior to these cavities.

SUPRAOCCIPITAL.—The portion of the supraoccipital exposed on the superior surface of the skull is very broad laterally, and very short antero-posteriorly; its posterior border is concave. On the posterior surface of the skull the supraoccipital extends downward about three-fifths of the distance from the superior border to the foramen magnum; its breadth is about three times as great as its height.

JUGALS.—The jugal bones are relatively short and broad; they occupy an unusually large area on the surface of the skull. Their sutures with the maxillaries are more nearly transverse than in most crocodilians. The sculpture of the bones is weak.

QUADRATO-JUGALS.—The quadrato-jugals are nearly smooth, the pitting being scarcely visible. The anterior points, which project into the infratemporal fenestræ in the living species of *Crocodylus* and *Tomistoma* may or may not have been present; the anterior ends of the bones are not completely preserved.

QUADRATES, EXOCCIPITALS, AND BASIOCCIPITAL.—These bones are characteristic in their great breadth and the stoutness of their construction.

PALATINES.—The palatine bones are remarkably short. They do not extend as far forward as the anterior ends of the palatine fenestræ, and their posterior ends are anterior to the level of the posterior ends of these fenestræ. The suture with the pterygoids is essentially transverse in direction. Their broadest portion is at the points where the maxillo-palatine suture reaches the fenestral borders. The narrowest portion is very slightly anterior to the posterior ends of the bones.

PTERYGOIDS.—The pterygoids are broad and flat; the flatness may be partially due to distortion. They occupy unusually large portions of the posterior borders of the palatine fenestræ. They occupy a greater area posterior to the internal narial aperture than in the modern crocodiles.

ECTOPTYERYGOIDS.—The three processes of each ectopterygoid are all short, but are all stoutly constructed. The lateral diameter is greater than in most crocodilians.

Measurements

Length of Skull, Supraoccipital to Tip of Snout	42.7cm.
Length of Skull, Ends of Quadrates to Tip of Snout	48.9
Breadth Across Quadrates	29.1
Breadth Across Posterior End of Cranial Table	13.7
Breadth Across Snout at Base	20.7
Breadth Across Snout at Level of Fifth Maxillary Teeth	14.4
Breadth Across Snout at Notch	8.3
Breadth Across Snout at Muzzle	9.7
Length of Snout	28.6
Length of Right Premaxillary on Superior Surface	12.8
Length of Premaxillaries on Palate	10.3
Length of Palatine at Median Line	11.0
Breadth of Pterygoids	18.2
Maximum Diameter, Right Supratemporal Fenestra	4.3
Maximum Diameter, Left Supratemporal Fenestra	4.7

Length, Right Orbit	6.2
Length, Left Orbit	6.8 (est.)
Breadth, Right Orbit	5.0
Breadth, Left Orbit	5.4
Length External Narial Aperture	3.7
Breadth External Narial Aperture	3.7
Length, Premaxillary Foramen	2.9
Breadth, Premaxillary Foramen	2.0
Length, Right Palatine Fenestra	12.0
Maximum Breadth, Right Palatine Fenestra	6.1
Length, Left Palatine Fenestra	11.6
Maximum Breadth, Left Palatine Fenestra	6.0
Breadth of Internal Narial Aperture	2.8

OTHER MATERIAL

Several other skulls appear to be conspecific with the one described. Of these, Amer. Mus. No. 6176 agrees very closely so far as comparison is possible. The skull is badly distorted, making direct comparison difficult. Amer. Mus. No. 1719 is well preserved but has not yet received sufficient preparation for accurate determination of characters. This specimen includes representative portions of nearly all parts of the skeleton. It will be described later. Amer. Mus. No. 4988 is similar in many respects and, when prepared for study, may prove to be conspecific. All of these specimens are from approximately the same horizon.

PLATE XVI

PLATE XVI

Skull of *Crocodilus* sp. cf *affinis* Marsh

Amer. Mus. No. 6177

About one-third natural size.

Superior view



PLATE XVII
Skull of *Crocodylus* sp. cf. *affinis* Marsh
Amer. Mus. No. 6177
About one-third natural size
Inferior view



Article XII.—THE SKULL OF *CROCODILUS ACER* COPE¹

BY CHARLES C. MOOK

PLATES XVIII AND XIX

Crocodylus acer was originally described by Cope in the American Naturalist in 1882. The original description was very brief, and no definite type was mentioned. A figure accompanying this description clearly indicates American Museum Cope Coll. No. 1240. In the 'Tertiary Vertebrata' Cope described this skull more fully and figured both superior and lateral aspects of it. He stated in this description that the skull was the only one in his possession and that it was collected in the Manti Beds of Utah. This second description brings out the essential characters of the specimen but is in error in at least one point and fails to sufficiently emphasize certain diagnostic characters. It is the purpose of the present description to redescribe the type, giving proper emphasis to its diagnostic characters.

GENERAL FORM

In general form the skull is long and narrow; the snout is slightly over twice as long as it is broad at the base. The region of the external narial aperture is relatively broad. The superior surface of the snout is very flat; the surface of the cranial table is scarcely elevated above that of the snout. The cranial table is considerably broader than it is long, and the space between the supratemporal fenestræ is relatively broad.

THE CAVITIES OF THE SKULL

SUPRATEMPORAL FENESTRÆ.—These fenestræ are comparatively small, and are relatively far apart; in outline they are nearly circular.

INFRATEMPORAL FENESTRÆ.—The infratemporal fenestræ are relatively large. They face more nearly upward than in most of the living crocodiles.

ORBITS.—The orbits are of moderate size. They are conspicuously pointed anteriorly. Their internal and posterior borders are symmetrical curves, and their external borders are straight oblique lines. They are considerably longer than broad.

¹Contributions to the Osteology, Affinities, and Distribution of the Crocodilia. No. 9.

EXTERNAL NARIAL APERTURE.—This cavity is unusually large; it is considerably larger than either of the supratemporal fenestræ. Its anterior border is broadly rounded and its lateral borders converge slightly in the posterior direction. The nasal bones enter the cavity as a sharp process.

PREMAXILLARY FORAMEN.—The premaxillary foramen is very large; it is somewhat longer than broad. Its anterior end is sharply pointed; the remainder of its outline is smoothly rounded.

PALATINE FENESTRÆ.—The palatine fenestræ are very long and narrow; their length is over twice their maximum breadth. Their inner borders are nearly parallel; their external borders extend from their anterior ends (slightly posterior to the ninth maxillary teeth) parallel with the external border of the jaw to the level of the posterior ends of the dental series, then bend sharply inward and backward to the posterior ends of the fenestræ. Both anterior and posterior ends are rounded, but not broadly.

INTERNAL NARIAL APERTURE.—The internal narial aperture is small; it is subcircular in form, and is situated near the posterior end of the pterygoid plate, farther back than in most Eocene crocodiles.

THE BONES OF THE SKULL

PREMAXILLARIES.—The premaxillary bones are very long and slender. They occupy nearly one-third of the total length of the skull. Their slender posterior processes extend back to the level of the fourth maxillary teeth.

On the palate the premaxillaries extend backward only as far as the level of the first maxillary teeth. The premaxillo-maxillary suture is exceedingly irregular.

MAXILLARIES.—These bones are very long and narrow. Their sutures with the nasals occupy only one-third of their total lengths. Their sutures with the lacrymals and jugals are more nearly antero-posterior than transverse in direction.

On the palate the length of the maxillaries along the median line is considerable. Along the median line the maxillaries meet the palatines at the level of the ninth maxillary teeth, only slightly anterior to the anterior ends of the palatine fenestræ. The total length of the maxillo-palatine suture is not great, the maxillaries occupying only a very small portion of the inner border of the palatine fenestræ.

NASALS.—Like the preceding bones, the nasals are long and slender. They enter the narial aperture as a slender process. They broaden

gradually from their anterior extremities to the point of their maximum breadth, along their contacts with the lacrymals. From that level back to their posterior ends they decrease in breadth very rapidly. About four-fifths of their total length is included in the area anterior to the broadest point.

LACRYMALS.—These bones are long and narrow. Their longest diameters converge slightly in the anterior direction. They are considerably larger than the prefrontals; their sutures with the maxillaries are irregular.

PREFRONTALS.—The prefrontals are small; they converge slightly in the anterior direction. Their anterior ends are sharp.

FRONTAL.—The frontal is characteristic in form. It narrows regularly from its point of greatest breadth posterior to the orbits to its contact with the nasals. The interorbital plate is moderately broad and is flat. The contacts of the frontal with the prefrontals are direct continuations of the orbital borders of the frontal; in most crocodilians the fronto-prefrontal sutures are directed sharply inward from the orbit, then turn sharply forward. The anterior process of the frontal narrows very gradually; at its very irregular contact with the nasals it still has considerable breadth.

POSTORBITALS.—These bones are very small. Each occupies less than one-third of the lateral border of the cranial table, and that only at the surface, the anterior processes of the squamosals projecting outward so as to be visible beyond the postorbitals. The orbital border of each postorbital is greater than its lateral border.

SQUAMOSALS.—The squamosal bones are very large, especially in their antero-posterior diameters. Each occupies more than two-thirds of the lateral border of the cranial table, and its antero-inferior process, which extends forward beneath the postorbital, projects outward so as to be visible from above.

The transverse diameter of each squamosal is relatively small; it occupies considerably less than one-third of the posterior border of the cranial table, in correlation with the large size of the parietal and supra-occipital bones.

PARIETAL.—This bone is large, especially in the transverse direction. With the supraoccipital it occupies over one-third of the posterior border of the cranial table; at least half of this space is occupied by the supra-occipital, however. The space between the supratemporal fenestræ is relatively large.

SUPRAOCCIPITAL.—As noted by Cope, this bone is very large. It is relatively larger than in any other crocodilian, either living or extinct, examined by the writer. It occupies over one-sixth of the posterior border of the cranial table and extends forward almost to the level of the posterior ends of the supratemporal fenestræ. On the posterior surface of the skull it extends downward two-thirds of the distance from the superior border to the foramen magnum.

JUGALS AND QUADRATO-JUGALS.—These bones are characterized by their long, slender form.

QUADRATES, BASIOCCIPITAL, AND BASISPHENOID.—These bones are not especially characteristic.

PALATINES.—The palatine bones are long and slender. They extend only slightly farther forward than the level of the anterior ends of the palatine fenestræ. They extend to the level of the ninth maxillary teeth, while the fenestræ extend only to the tenth. The broadest portion is at the level of the eleventh maxillary teeth. The posterior end is anterior to the level of the posterior ends of the fenestræ. The palatine-pterygoid suture is irregular and nearly directly transverse in direction. The two palatines together are little, if any, broader at their posterior ends than farther forward.

PTERYGOIDS.—The pterygoids are incompletely preserved, but enough remains to indicate that they were very short antero-posteriorly and broad laterally. They extend forward between the palatine fenestræ for a short distance.

ECTOPTYRGOIDS.—The superior and anterior processes of the ectopterygoids are slender, and the postero-inferior process is stout. The anterior processes extend forward to the level of the twelfth maxillary teeth and lie internal to four maxillary teeth on each side. The ectopterygoids occupy over two-thirds of the external borders of the palatine fenestræ.

Measurements

Length, Total	38.7cm.
Length, Tip of Snout to Occipital Condyle	35.5
Length, Tip of Snout to Supraoccipital	34.0
Length of Snout	23.5
Breadth of Skull Across Quadrato-jugals	18.7
Breadth of Cranial Table, Anterior End	8.9
Breadth of Snout at Base	11.4
Breadth of Snout at Fifth Maxillary Teeth	6.95
Breadth of Snout at Notch	4.9
Breadth of Snout at Fourth Premaxillary Teeth	5.7

Length of Right Orbit	5.0
Length of External Narial Aperture	3.8
Length of Premaxillary Foramen	2.5
Length of Right Palatine Fenestra	9.6

PLATE XVIII

Skull of *Crocodylus acer* Cope

Amer. Mus. Cope Coll. No. 1240, type specimen

About one-half natural size

Superior view

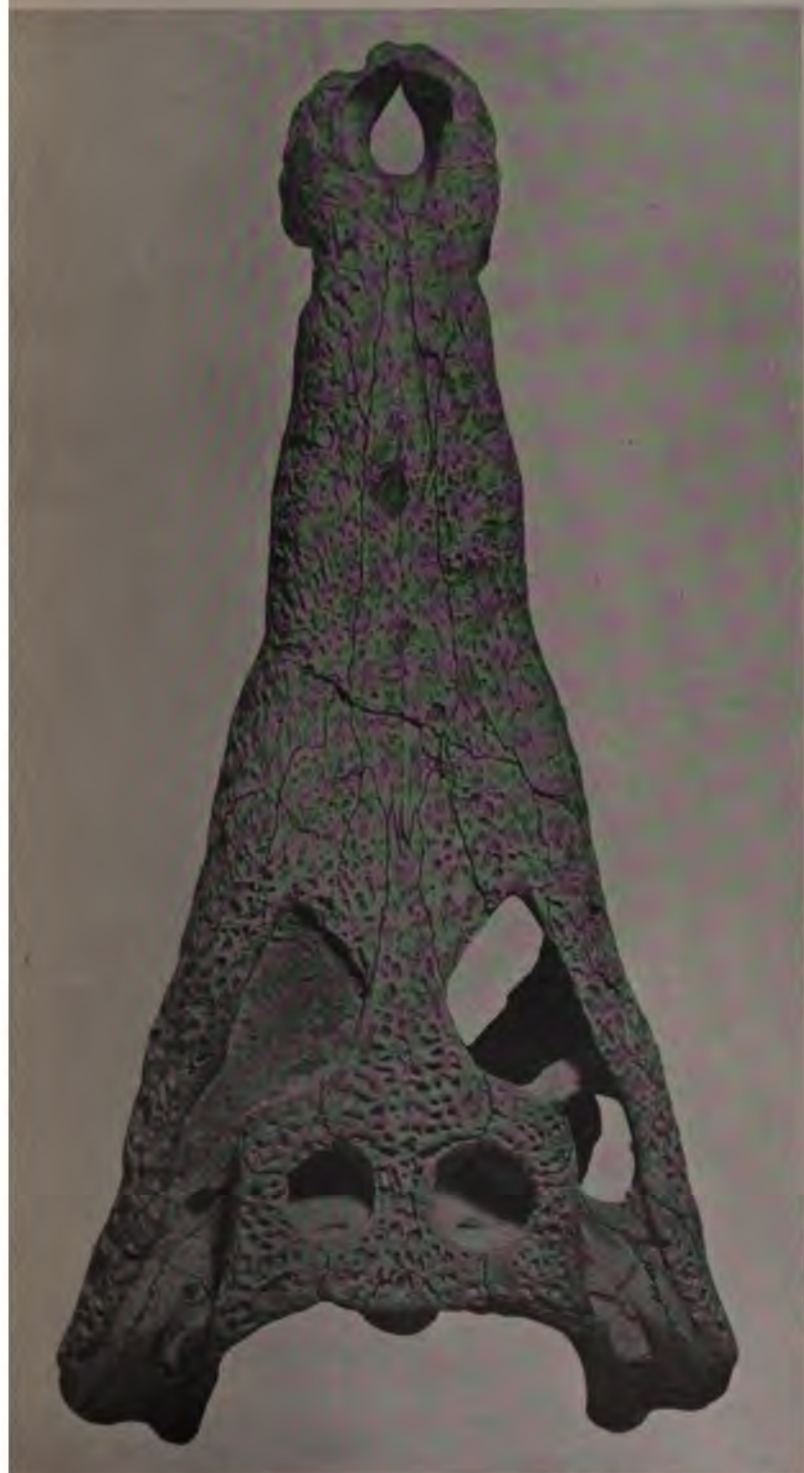


PLATE XIX

Skull of *Crocodilus acer* Cope
Amer. Mus. Cope Coll. No. 1240, type specimen
About one-half natural size
Inferior view



1000

**Article XIII.—SKULL CHARACTERS OF RECENT CROCODILIA,
WITH NOTES ON THE AFFINITIES OF THE RECENT
GENERA¹**

BY CHARLES C. MOOK

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INTRODUCTION

The present studies of the skull characters of modern crocodilians were made to afford a basis of comparison for fossil species. To the writer's knowledge no complete descriptions of the skulls of the various living crocodiles have been published, although many works of great value are available. Schneider, Wagler, Spix, Gray, Cuvier, Duméril and Bibron, Müller, Gadow, Huxley, and others have either summarized the characters of the living species, or described some of them in great detail. L. C. Miall's study of the crocodilian skull is a work of very great value; Brühl's atlas contains useful comparative figures and descriptions. Boulenger's catalogue is the most complete and up to date summary; it has been followed closely in the present studies, and the specific nomenclature and synonymy has been adopted, except in the case of the caimans, which Boulenger groups into one genus, and which are here considered as members of two genera, following the usage of Huxley. Schmidt's recent work on the Congo reptiles contains valuable figures of the African crocodilians, with notes on their structure and habits, besides a description of a new genus.

The writer is indebted to Prof. H. F. Osborn and Dr. W. D. Matthew for the opportunity to make the studies here summarized. Prof. Osborn, Dr. Matthew, and Prof. W. K. Gregory have all made valuable suggestions. The members of the Department of Herpetology have assisted in making the extensive collections of Recent Crocodilia available for study. Dr. Thomas Barbour placed the great collections of the Museum of Comparative Zoology at the writer's disposal for study, and has loaned many specimens of species otherwise unavailable. Dr. A. G. Ruthven, of the University of Michigan, has loaned several skulls of South American crocodilians, and Dr. A. S. Pearse, of the University of Wisconsin, has aided in securing material for study. The drawings were prepared by Mr. E. S. Christman and Mr. Wesley Seim.

In these descriptions characters common to all crocodilians have been omitted, so far as possible; the purpose of the descriptions is for comparison, and the attempt was made to render the descriptions of the various parts of the skulls comparative in nature.

Characters which have hitherto been used in limiting genera and species of crocodilians include the following list: size, proportions, especially in regard to the relative length and breadth of the snout, general form of the skull, size and relative positions of the supratemporal fenestræ, size and relative positions of the orbits, single or double character of the external narial aperture, shape of the premaxillo-maxillary

suture on the palate, shape of the maxillo-palatine suture on the palate, size and shape of the palatine fenestræ, irregularities on the snout, degree of ossification of eyelids, number, position, and relative sizes of the premaxillary teeth, the character of the spaces between the teeth, the manner of interlocking of premaxillary and maxillary with mandibular teeth, especially in regard to the presence of a pit or a groove on each side of the upper jaw to receive the fourth mandibular tooth, the number of teeth in the mandible, the length of the symphysis of the mandible, and the presence or absence of the splenial bones in it, the appearance or absence of the prevomers at the surface of the palate, the presence or absence of a small process of each quadrato-jugal into the infratemporal fenestra, besides many characters of the postcranial skeleton, and of the dermal covering, color, etc., with which the present studies are not concerned.

In addition to these characters others may be noted, namely: the contact or separation of the lacrymal bones with the nasals, the presence of the parietal along the posterior border of the cranial table or its absence, the extent of the supraoccipital upon the cranial table (correlated with the last-mentioned character), the shape of the cranial table, the size and shape of the external narial aperture, the size and shape of the small premaxillary foramen on the palate, the direction of the teeth, the position and form of the internal narial aperture, besides many small, but constant variations in the outlines and relations of most of the component bones.

Characters which might be explained as due to individual or age variation have been eliminated, or specially explained, so far as possible; they have been treated elsewhere as the subject of a separate study. Adaptive characters have been noted in some cases, but no attempt was made to consider this topic fully. In the descriptions a large number of individuals was used whenever possible, eliminating to a large extent the danger of describing age or individual characters as specific; in the species of which only one or two specimens were available, the characters were analyzed for possibilities of individual or age variation before incorporation in the specific descriptions. The comments on the relationships of the various genera are based upon an analytical study of the characters of the genera, keeping in mind distinctions between palæotelic and cænotelic characters, as emphasized by Professor Gregory.

Sixteen species are described more or less fully and fourteen are figured; the description of characters of the four species of which no material was available (*Crocodilus johnstoni*, *C. siamensis*, *Caiman palpe-*

brosus, and *Alligator sinensis*) is adapted from published descriptions, partly verified from alcoholic specimens.

In all forty-five specimens were carefully studied, and about fifteen more were examined for comparison and verification. The distribution of these specimens among the genera and species is as follows: *Gavialis gangeticus* 1, *Tomistoma schlegelii* 2 (+1), *Crocodylus cataphractus* 1, *C. intermedius* 1, *C. americanus* 11 (+6), *C. niloticus* 1 (+1), *C. porosus* 3 (+2), *C. rhombifer* 1, *C. palustris* 1 (+1), *Osteolemus tetraspis* 1, *Osteoblepharon osborni* 1, *Jacare niger* 2, *J. sclerops* 8, *J. latirostris* 1, *Caiman trigonatus* 1, *Alligator mississippiensis* 9 (+5 or 6). This does not include some dried and alcoholic specimens which were also used for verification of some characters.

GAVIALIS Cuvier

GENERIC CHARACTERS

The skull of this species is excessively long and slender. Boulenger states that the generic characters are: "27 to 29 upper and 25 or 26 lower teeth on each side, anterior largest, laterals subequal, not received into interdental pits; the first, second, and third mandibular fitting into notches in the upper jaw. Snout extremely long and elongate, dilated at the end; nasal bones comparatively short, widely separated from the premaxillaries; nasal opening smaller than the supratemporal fossæ; lower anterior margin of orbit (jugal) raised; [this raised margin also includes lacrymal and prefrontal] a very small anterior bony plate in the upper eyelid. Mandibular symphysis extremely long, extending to the 23rd or 24th tooth, comprising the splenial bones." Each quadratojugal possesses a small anterior process which projects into the infra-temporal fenestra.

The characters of the genus differ widely from those of the other living crocodilians. In spite of the fact that *Tomistoma* is in many respects intermediate between this genus and *Crocodylus*, there is no appreciable gradation in characters between the gavial and the true crocodiles, *Tomistoma* being much closer to *Crocodylus* than to *Gavialis*. The excessively long snout, the abrupt expansion at its base, the extremely large supratemporal fenestræ, the separation of the nasals from the premaxillaries, the large number of teeth, and the exceedingly long mandibular symphysis are all resemblances to the Mesozoic marine crocodiles. It is quite probable that *Gavialis* was either derived independently from the other Eusuchian crocodiles, or was separated from the primitive Eusuchian stem near its base. It certainly approaches their condition much more closely than does any other living crocodile.

***Gavialis gangeticus* (Gmel.)**

The description of the skull of this species is based chiefly upon a single specimen in the American Museum Collections (Amer. Mus. No. 15176), and to a slight extent upon published descriptions.

General Form

The general form of the skull of this species is strikingly different from that of any other living crocodile. The detailed form of the various component bones is equally at variance with the typical crocodilian skull.

The snout is excessively long and narrow. Its length is over three times its breadth at the base. Boulenger states that young individuals of this species have snouts five and one-half times as long as broad at the base. From the base of the snout forward the latter narrows rapidly, so that throughout the greater part of its length its lateral borders are parallel. At the tip it is greatly expanded; the expansion extends back to a point a short distance anterior to the lateral vertical element of the premaxillo-maxillary suture. The postero-external borders of this expanded portion are convexly rounded, and are sharply separated from the lateral borders of the snout posterior to them; the antero-external borders of the expansion are nearly straight lines; they are excavated below the level of the surface of the snout for reception of the first mandibular teeth. On each side of the anterior expansion of the snout, on its superior surface is an irregular, more or less sharp process, and posterior to this a smaller one of like nature. The longitudinal profile of the snout is very slightly concave.

Anterior to, also slightly below each orbit is a prominent ridge of bone, made up of components of a number of the bones of the skull; this ridge elevates the external opening of the orbit a considerable distance above the level of the snout. The interorbital space is very broad. The cranial table is very broad laterally, but is relatively short antero-posteriorly. Its lateral borders are parallel; they are not simple edges, but are somewhat grooved. The posterior border is composed of two concave loops. At a lower level than the posterior surface of the cranial table the posterior surface of the skull extends backward in a complex process, or group of processes, all composed of the supraoccipital bone. In most crocodilian skulls these processes are largely hidden under the posterior edge of the cranial table.

On the palate a pair of bulbous expansions of the nasal passage occupy conspicuous positions at the posterior ends of the palatine fenestræ, and extend upward from them toward the roof of the skull.

The Cavities of the Skull

SUPRATEMPORAL FENESTRÆ.—The supratemporal fenestræ are far larger in size than in any other Recent crocodilian. Each of them is much larger than the external narial aperture, which itself is large. The cavities are irregularly rounded, and their transverse diameters are greater than their longitudinal. They are separated a moderate distance from each other. They bear closer resemblance to the supratemporal fenestræ of some of the extinct tomistomoid crocodilians, or in fact to those of some of the Mesozoic marine mesosuchian crocodiles, than to those of any other living species.

INFRATEMPORAL FENESTRÆ.—These fenestræ differ very greatly from the infratemporal fenestræ of other modern crocodiles. They are not triangular, as in most species, but rounded; their length is greater than their height, and they are higher near their anterior than near their posterior ends. They are penetrated at their posterior ends by sharp processes of the quadrato-jugals, much as in the species of *Crocodylus* and *Tomistoma*; the processes are somewhat different in form from those of the other genera, however.

ORBITS.—The orbits are large and round; they are separated far from each other by a concave interorbital plate. Each of them is almost completely encircled by a rim of bone, which separates it off more or less sharply from the surrounding portions of the skull. At the posterior end this rim is the anterior portion of the cranial table, and is relatively low; the internal portion is somewhat higher, and the anterior and antero-inferior portions are very greatly elevated. The postero-inferior boundary of the orbit, or postorbital bar, is situated at a very distinctly lower level than the circumorbital ring.

EXTERNAL NARIAL APERTURE.—This cavity is very peculiar in its shape. It consists of two more or less distinct portions, a posterior one, which extends down into the nasal passage, and an anterior, shallow one, which does not extend into the nasal passage, and is more or less accessory to the posterior one. The posterior element of the aperture is large, and it is roughly triangular in outline, with the apex of the triangle directed backward. Its borders, except the anterior one, are nearly vertical. The anterior border forms the floor of the anterior element of the aperture. It is inclined in position, sloping downward toward the posterior portion. Its anterior edge, at the surface of the snout, is concave backward.

PREMAXILLARY FORAMEN.—The premaxillary foramen on the palate is very small, and is simple in outline. It has two borders only, and

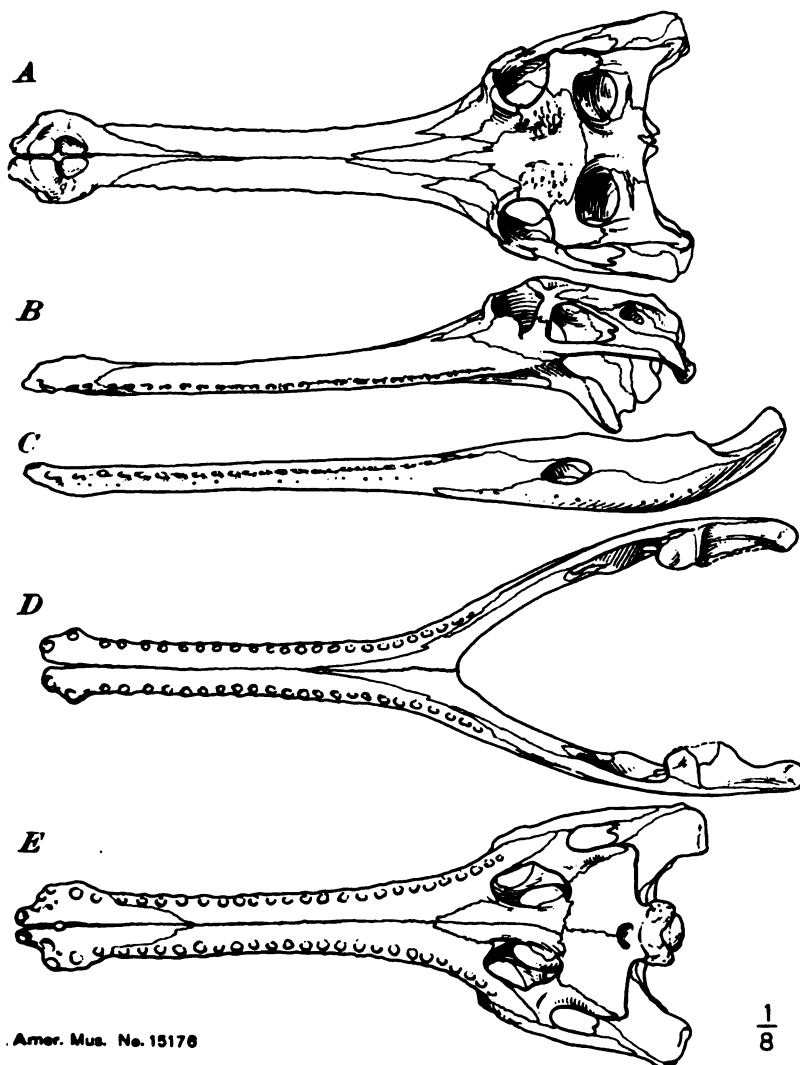


Fig. 1. Skull and jaws of *Gavialis gangeticus* Gmel. Amer. Mus. No. 15176, one-eighth natural size. A, superior view of skull; B, lateral view of skull, left side; C, lateral view of mandible, left side; D, superior view of mandible, left side; E, inferior view of skull.

these are lateral in position; they are concave curves, which meet at the anterior and posterior ends, giving the cavity sharp anterior and posterior ends. The length and breadth of the cavity are equal.

PALATINE FENESTRÆ.—The palatine fenestræ are different in shape and in position from those of any other living crocodile. They are short antero-posteriorly, and are relatively broad, the length of each being considerably less than twice its breadth. They extend forward to the level of the twenty-second maxillary teeth. Their anterior ends are somewhat rounded, but are not far from being pointed. Their posterior ends are somewhat irregular. Their external borders are composed of two distinct portions, which are approximately equal in length; one of these is properly an antero-external border, and the other a postero-external border. The internal border, considered at the level of the palate only, and neglecting the great bulbous expansion of the nasal passage, is a simple concave edge. The great expansion mentioned above, however, spreads out laterally into each fenestra, and then bends toward the palatine surface; the lower surface of each side of this great expansion grades into the surface which forms the internal wall of the fenestra, greatly complicating the internal outline of the latter.

INTERNAL NARIAL APERTURE.—The internal narial aperture is relatively small. Its breadth is about twice its length; its length is about one-fifth of the median antero-posterior diameter of the combined pterygoid bones. It is not separated into two portions by a median septum, but it has a small median process projecting forward from its posterior wall. It is not protected from any direction, at the surface of the palate, by an elevated plate of bone.

The Bones of the Skull

PREMAXILLARIES.—The premaxillaries are totally different from those of any other living crocodilian. Surrounding, as they do, the external narial aperture, they partake of its unusual characters. On the superior surface of the skull the premaxillo-maxillary sutures are somewhat different from those of other forms. They extend inward and backward from the sides of the snout for a short distance, on each side, then gradually turn farther and farther backward in direction, until near their posterior ends they are nearly antero-posterior in direction. Together they make a figure much like a letter V whose sides are not straight lines, but are curves which are convex toward each other, the curves being irregular and not smooth. In the skull studied the two premaxillaries differ very greatly in the backward extension of their posterior processes.

The right premaxillary extends back as far as the level of the fifth maxillary teeth; the left one extends back as far as the level of the seventh maxillary teeth; as the maxillary teeth are far apart this difference is considerable; it may be interpreted merely as the result of individual variation.

The two prominences on either side of the aperture are of course carried on the premaxillaries. In an antero-lateral direction from the aperture each premaxillary descends sharply downward in a nearly vertical plane. The ends of this plane are extended into prominences which lodge teeth, but the central portion is excavated to make space for the first mandibular tooth, which bites completely outside of the upper jaw. At their anterior ends the premaxillaries are extended forward into two processes which on their inferior surfaces lodge the first premaxillary teeth.

On the palate the premaxillaries extend backward to the level of the fourth maxillary teeth, the premaxillo-maxillary suture forming a flaring V. The teeth are not preserved in the specimen examined, but their alveoli indicate that there were five teeth in the left premaxillary, and four in the right. The fourth premaxillary teeth are evidently the largest, with the first and third only slightly smaller. The second is considerably smaller, and so is the fifth. The alveoli of all of these teeth point forward and outward. The first and second are far apart, and are separated by excavations which lodged the first mandibular teeth. The second and third, on the side in which the second is present, are very close together. The third and fourth are far apart, and are separated by spaces which are partly pits and partly notches; these lodge the second mandibular teeth. The fourth and fifth are moderately far apart. Posterior to the fifth alveoli are excavations which are partly in the form of notches, but which have pits at their internal margins; these lodged the fourth mandibular teeth; they correspond with the so-called canine notches of the true crocodiles. The palatal surfaces of the premaxillaries face outward as well as downward. The anterior portion of each premaxillo-maxillary suture is situated far out near the lateral margin of the jaw; the internal wall of the alveolus of the first maxillary tooth is partly composed of the premaxillary bone.

MAXILLARIES.—The maxillaries of this form are exceedingly long and slender. Their sutural contact with the premaxillaries has been described above. They differ from the maxillaries of all other living crocodilians in meeting each other along the median line, excluding the nasals from contact with the premaxillaries; the median contact of the

maxillaries with each other is moderately long. The contact of each maxillary with its neighboring nasal is slightly longer than the median maxillary suture. The suture with the lacrymal extends almost directly forward from the posterior end of the maxillo-nasal suture, then turns backward and slightly outward to the anterior end of the jugal; the maxillo-jugal suture extends more directly outward and downward in its anterior portion, then turns backward. From the outline of the maxillo-lacrymal suture it will be seen that a process of the maxillary extends backward from the main superior plate of the bone, wedging the lacrymal apart from the nasal; it does not separate the lacrymal from the nasal entirely, however. The posterior process of the maxillary is very slender. The teeth of the maxillaries are situated on small pedicles, which are separated by notches which lodge the mandibular teeth. The result of the alternation of the pedicles with the notches is a crenulation of the border of the snout, which is visible not only on the inferior and lateral surfaces of the skull, but also when the skull is viewed from above.

The suture of the maxillaries with the premaxillaries on the palate has been described above; the suture with the palatines is relatively simple. It extends inward and slightly backward from a point on the internal border of the palatine fenestra, very slightly posterior to its anterior end, for a very short distance, then turns directly forward to a point opposite the twenty-first maxillary tooth, then forward and inward, meeting the median line at the level of the eighteenth maxillary teeth, and in a symmetrical direction to the opposite palatine fenestra. The maxillaries thus form very small portions of the internal borders of the palatine fenestræ, as well as small portions of their external borders. Their sutures with the ectopterygoids reach forward to the level of the twenty-third maxillary teeth; from this point they extend backward and outward for a considerable distance on each side. The transverse profile of the maxillaries on their palatine surfaces is decidedly convex.

Each maxillary contains twenty-three teeth; they are all of approximately the same size, except the last two on each side, which are slightly smaller. All of the teeth are relatively small. The teeth themselves are not preserved in the specimen studied, consequently their exact form cannot be described; evidently they were long and slender, from the form of the alveoli and their intervening notches. The alveoli are directed downward, forward, and outward; the teeth evidently extend in the same direction, the maxillary and mandibular teeth crossing each other at oblique angles. The alveoli are all moderately far apart, except in the posterior region, where some of them are close together.

NASALS.—The nasal bones are very characteristic in form. They are very short, extending only as far forward as the level of the spaces between the thirteenth and fourteenth maxillary teeth. They broaden rapidly in the posterior direction, and reach their maximum spread at the level of the twentieth maxillary teeth; at this point, however, they are separated by the median anterior process of the frontals, which wedges them sharply apart for a distance equal to one-third of their entire length. On the right side the suture of the nasal with the lacrymal is about one-half the length of the suture between the nasal and the prefrontal. On the left side the suture of the nasal with the lacrymal is considerably longer than the irregular suture of the nasal with the prefrontal. At their posterior ends, between the median process of the frontal and the prefrontal borders of the nasals, the latter are penetrated on each side by a small, sharp, minute process of the frontal; the entire naso-frontal contact is therefore very irregular.

LACRYMALS.—The lacrymal bones of this species are large; they are also very unusual in their shape. Their sutures with the prefrontals are concave, in a very irregular way; the posterior portions of their sutures with the maxillaries, also their sutures with the jugals, are convex; their sutures with the nasals, and the anterior portions of their sutures with the maxillaries are nearly antero-posterior in direction. Their external and internal borders, therefore, consist of two nearly concentric edges, which converge anteriorly, giving the bones very sharp anterior ends. These anterior processes are separated from the nasals by the sharp posterior processes of the maxillaries mentioned above. The posterior, or orbital, borders of the lacrymals are abruptly elevated into the prominent anterior portions of the circumorbital ridges; the lacrymal portions of these ridges not only stand vertical, but for a short distance on each side slightly overhang. The anterior processes extend forward to the level of the eighteenth maxillary teeth.

PREFRONTALS.—The prefrontal bones are smaller than the lacrymals, but are somewhat similar in shape; they are relatively shorter, however, and their nasal borders converge posteriorly. Their orbital borders are considerably elevated.

FRONTAL.—This bone is very large. Its anterior process, which wedges apart the posterior ends of the nasals, is long and broad. The portion of the bone between the two prefrontals is broad, but is short antero-posteriorly. The interorbital plate of the frontal is excessively broad; it merges into the still broader postorbital portion, which extends back to the supratemporal fenestræ, and forms part of their anterior

borders. The interorbital and posterior portions of the bone are very rough from deep, greatly elongated pits.

POSTORBITALS.—The postorbital bones are of moderate size; in proportion to the small squamosals they are large. They occupy about two-fifths of the lateral borders of the supratemporal fenestræ; the sutures with the squamosals extend obliquely downward and forward along the edges of the thick roof of the cranial table. The orbital borders are nearly as long as the lateral borders, and are nearly at right angles with them. Each postorbital sends a long narrow process of bone inward between the frontal and the parietal, along the anterior wall of the supratemporal fenestra; this wall of the fenestra is thus composed of three bones, the frontal at the surface, the postorbital slightly lower, and the parietal still lower, besides the alisphenoid at a still deeper level. The distance between the orbits and the supratemporal fenestræ, across the postorbital bones, is considerably greater than the distance between the fenestræ and the posterior border of the cranial table, across the squamosal bones.

SQUAMOSALS.—The squamosals bones are small so far as surface area is concerned. On the superior surface of the skull they are triradiate in form, one process extending outward and backward, another forward, and the third inward. All of these processes are slender. Each squamosal occupies about one-third of the posterior border of the cranial table. The small triangular area where the three processes come together on each squamosal is deeply pitted. The squamosal bones of this species do not resemble those of any of the other modern crocodilians so much as they do some of the Tertiary tomistomoid species or the Mesozoic marine crocodiles.

PARIETAL.—At the surface of the skull the parietal is broader posteriorly than anteriorly, the reverse condition from most crocodilians; at a deeper level, however, the anterior ends spread out, and are broader than the posterior. The median portion of the bone, between the two supratemporal fenestræ, is narrow. The posterior part is over three times as broad as the interfenestral portion. The posterior portion extends backward as a median posterior process of the cranial table. It occupies about one-third of the posterior border of the cranial table, including a minute superior surface of the supraoccipital.

SUPRAOCCIPITAL.—This bone occupies only a very minute area on the superior surface of the skull, and extends back from it as a pair of slight median processes. The two processes which are usually covered by the overhanging surface of the cranial table project out beyond it in

this form. The breadth of the bone, on the posterior surface of the skull, is slightly over one-fourth of the total breadth of the cranial table. Vertically, the supraoccipital occupies about three-fourths of the distance between the superior border and the foramen magnum.

BASIOCCIPITAL.—This bone is rather more massive and compact than in most crocodilians; otherwise it is not especially characteristic.

QUADRATES.—The quadrate bones are rather short antero-posteriorly; their sutures with the quadrato-jugals are exceedingly irregular.

EXOCCIPITALS AND BASISPHENOID.—These bones are not especially distinctive.

JUGALS.—The jugals are very long antero-posteriorly, but most of their length is in their posterior portions. The anterior, or facial, portions of the jugals are very short; they do not extend nearly as far forward as the lacrymals. The infraorbital portions of the jugals are greatly expanded vertically, forming parts of the great circumorbital ridges, which partly cover the orbital cavities on their inferior borders. The posterior portions of the jugals are exceedingly long and slender.

QUADRATO-JUGALS.—The quadrato-jugals of this form are very characteristic. They are very short antero-posteriorly, and their sutures with the quadrates superiorly, and with the jugals inferiorly, are very irregular. The antero-superior process of each quadrato-jugal is long and slender, and has a rather long contact with the postorbital. The left one has a prominent process extending forward into the infratemporal fenestra, and there is a broken base of one on the right side. The anterior process differs considerably from that of the true crocodiles and *Tomistoma*. It is not a continuation of the inferior portion of the bone upward and forward as in the other genera, but is distinctly elevated above the level of the principal surface of the bone posterior to the border of the fenestra. It is rather stout, and it extends directly forward; it is moderately sharp. Below this anterior process the bone extends a considerable distance forward, and forms a part of the inferior border of the fenestra. This antero-inferior process is considerably longer than the process which penetrates the fenestra.

PALATINES.—The sutures of the palatine bones with the maxillaries have been described above. The anterior processes of the palatines which they partly enclose form a broad wedge, which extends forward to the level of the eighteenth maxillary teeth. The very short lateral processes form most of the anterior borders of the palatine fenestræ. From the bases of these lateral processes the palatines narrow in the posterior direction to a level a short distance anterior to their posterior

ends, then expand again. At the palatal surface this posterior lateral expansion is not great, but at a deeper level, the palatines support the great expansions of the pterygoids with thin downwardly deflected plates. The sutures with the pterygoids are relatively simple in their posterior palatal portions, but are complicated somewhat by their anterior extensions along the great pterygoid expansions. On each side the suture extends backward from a point immediately posterior to the superior process of the palatine which extends upward to meet the inferior process of the prefrontal, and turning at the level of the minimum breadth across the palatines, extends backward and outward across the floor of the pterygoid expansion; near the posterior end of the fenestra it turns sharply inward, backward, and upward to a point a short distance posterior to the posterior end of the palatine fenestra then extends in an irregular but gentle curve to the median line, at a point directly between the posterior ends of the two fenestræ, and thence in a symmetric direction on the opposite side.

PTERYGOIDS.—The pterygoids of this form are unique among the Crocodilia. Their posterior, or palatal, portions differ only slightly from those of other species; this palatal portion is relatively flat, and is very broad in proportion to its length. The posterior nasal aperture occupies only a small portion of the median line. The anterior portions, which extend forward over the palatines, are expanded into huge bulbous processes, which extend in every direction for considerable distances into the great pterygoid fossæ. Anteriorly they extend nearly to the vertical columns formed by the prefrontal and palatine bones, and the median anterior pterygoid process extends forward between these columns articulating with the prefrontals. Each of the great expansions is shaped much like a hen's egg, and is similar in size. These great expansions are evidently correlated with the more completely aquatic habits of the animal, compared with other Recent crocodilians.

ECTOPTYRGOIDS.—The anterior processes of the ectopterygoids are small, being both short and slender. The postero-inferior processes are broad, but are not especially thick; the superior processes are small. The sutures with the maxillaries are short themselves, but are long in comparison with the abbreviated length of the anterior processes; these sutures converge very sharply in the anterior direction.

The Mandible

The mandible of the gavial is unique among modern crocodilians, and bears considerable resemblance to the mandibles of some of the Mesozoic marine crocodiles. The two rami together are very slender back to the level of the twentieth or twenty-first mandibular teeth, then broaden rapidly.

The symphysis is exceedingly long, extending back to the level of the twenty-third mandibular teeth. The splenial bones form very extensive portions of the symphysis. They extend forward to the level of the spaces between the thirteenth teeth; at the posterior end of the symphysis they are broad, together comprising at least two-thirds of the breadth of the symphysis; they thus wedge apart the dentary portions of the symphysis. Nearly half the length of the splenials is included in the symphysis.

Each ramus contains twenty-five dental alveoli. The first of these is the largest, the second next in size, and the fourth next. The remainder are all about equal in size and small. All of the alveoli are directed strongly forward, and slightly outward, as well as upward; the surface of the symphysis, between the two dental borders, is convex. The first teeth are considerably separated from each other. The mandible is as broad at this point as farther back near the fifth, or tenth teeth. The first teeth are separated by considerable spaces from the second; the two second alveoli are separated widely from each other, the broadest portion of the anterior end of the symphysis being between them. The second teeth are very widely separated from the third; the third are rather far from the fourth, and the fourth from the fifth. Back of the fifth the teeth are all approximately equally far apart, the distance being considerable between each successive pair. All of the alveoli are contained in slight pedicles, which are separated from each other by relatively flat areas. The pedicles extend outward slightly from the lateral borders of the symphysis, giving these borders a remarkably crenulated appearance.

The dentary bones are exceedingly long; the splenials are also very long, but the remainder of the mandibular bones are little, if any, longer than in other crocodiles. The external mandibular foramina are small.

The two rami of the mandible spread apart from each other considerably at their posterior ends. The skull and jaws of the gavial taken together have been described as resembling a frying pan in shape, the handle of the pan corresponding with the snout, and the basin of the pan with the cranial portion of the skull.

Measurements Amer. Mus. No. 15176

Length of Skull, Tip of Snout to Supraoccipital	.680M.
Length of Skull, Tip of Snout to Ends of Quadrates	.712
Length of Snout	.500
Breadth of Skull, Across Quadrato-jugals	.284
Breadth of Skull, Across Cranial Table	.200
Breadth of Snout, at Base	.160
Breadth of Snout, at First Maxillary Teeth	.064
Breadth of Snout, at Third Premaxillary Teeth	.102
Length of Mandible, Total	.815
Breadth of Mandible, Total	.306

TOMISTOMA Müller

GENERIC CHARACTERS

This genus has twenty to twenty-one upper teeth on each side, and eighteen to twenty lower teeth; these numbers may be increased somewhat if some fossil species are included; the lateral teeth are received into pits between the teeth of the opposing jaw; the premaxillaries have five teeth in the younger stages, but only four in the adult condition; the fifth maxillary tooth is usually somewhat enlarged as in *Crocodylus*. The snout is long and slender, but less so than in the gavial; it resembles that of *Crocodylus cataphractus* in general form. The nasal bones do not enter the external narial aperture, but they do have contacts with the premaxillaries, differing in the latter respect from the gavial. The mandibular symphysis is very long, extending back to the level of the fourteenth or fifteenth teeth, and including the anterior ends of the splenial bones. The supratemporal fenestræ are small. The quadrato-jugals possess sharp anterior processes which penetrate the infratemporal fenestræ. The prevomers appear on the palatal surface at the mid-line posterior to the maxillaries.

This genus approaches the true crocodiles in many characters, while its resemblances to the gavial appear to be more or less superficial; it is here considered to be an off-shoot of the central crocodilian stem, which has assumed habits somewhat like those of the gavial, and has developed secondary characters which resemble the characters of that form.

Tomistoma schlegelii Müller

The description of the skull of *Tomistoma schlegelii* is based upon two skulls, one very large (Amer. Mus. No. 15177), and the other of medium size (Mus. Comp. Zool. No. 12459), also upon the published descriptions.

General Form

The skull of this species is long and slender, but not to the same extent as in the Indian gavial; in general form the resemblance to *Crocodylus cataphractus* is considerable, but the details of the skull are different from those of the latter species.

The snout is especially long and slender; its length varies from two and three-fourths to three and two-thirds times its breadth at the base; it tapers gradually from its base to its tip, differing in this respect from the true gavial. The superior antero-posterior profile of the snout is very slightly concave; the vertical depth of the snout is considerable; the lateral borders of the snout are rather smooth when viewed from above; there is a very slight expansion in the premaxillary region, and a rather abrupt broadening, on a small scale, at the level of the fifth maxillary teeth, otherwise the borders are simple slightly concave lines. It is very slightly expanded posterior to the lateral portions of the premaxillo-maxillary suture. When viewed from the side the snout, especially in the premaxillary region, is very irregular along its inferior, or dental, margin, due to the great size of the pedicles of the teeth, and the depth of the spaces between them.

The cranial table is relatively small; in comparison with the Indian gavial it is very small. Its lateral borders are more or less irregular, but in general have a strong tendency toward convergence at their anterior ends. The posterior border is concave, and is indented at the median line; this indentation is both horizontal and vertical; in form it resembles a miniature glacial cirque. In transverse profile the cranial table is concave. The skull has the appearance, while long and slender, of being stout and strong.

The Cavities of the Skull

SUPRATEMPORAL FENESTRÆ.—These cavities are of moderate size. In the large skull studied each fenestra is equal to, or slightly larger than, the external narial aperture; in the smaller skull the fenestræ are each somewhat larger than the narial aperture. The fenestræ are rounded on their posterior and postero-internal borders, but their external and antero-internal borders are nearly straight lines, which converge anteriorly, making a sharp angle at the antero-external corner of each fenestra. The interfenestral space is very narrow.

INFRATEMPORAL FENESTRÆ.—These cavities are rather large, about equaling the supratemporal fenestræ in size. Each of them is subtriangular in outline; none of the borders are either horizontal or vertical

in position. Viewed from the side the vertical diameter of each fenestra is very much less than the antero-posterior diameter; this condition is slightly exaggerated by the slight upward trend of the jugal bones. Each fenestra is penetrated by a long sharp process of the quadrato-jugal, much as in the species of *Crocodylus*.

ORBITS.—The orbits are large; their longitudinal diameters are greater than their transverse. Their lateral borders converge slightly in the anterior direction, but their anterior ends are rounded and not sharp.

EXTERNAL NARIAL APERTURE.—The external narial aperture is relatively large. Its vertical depth is considerable; its postero-external and posterior walls converge slightly downward; its antero-external walls are vertical, and its anterior wall is slightly overhanging. It is longer than broad, and is broader near its anterior than near its posterior end. Its postero-external borders converge backward, but do not meet, there being a short posterior border between their ends. There is no forward extension of the premaxillaries at the posterior end at the level of the surface, but these bones do make a very slight process at a greater depth; the nasals are excluded from the aperture altogether by the premaxillaries. The borders of the aperture are not elevated.

PREMAXILLARY FORAMEN.—The premaxillary foramen on the palate is heart-shaped, and is exceedingly small in size. It is situated directly between the second (primitively the third) premaxillary teeth.

PALATINE FENESTRÆ.—These cavities are large; they are triangular in outline, differing in this respect from all other Recent crocodiles. The borders are internal, antero external, and postero-external; the first of these borders is nearly straight, but is very slightly concave, and is nearly antero-posterior in direction; it is the longest of the three borders. The antero-external border of each is second in length, and the postero-external is the shortest, being about half the length of the antero-external. The two external borders make angles of slightly over 90° with each other. The anterior ends are accordingly sharp, the posterior ends less so, and the external angles almost right angles. The fenestræ extend forward to the level of the spaces between the twelfth and thirteenth maxillary teeth in the smaller specimen, and about to the level of the posterior edges of the thirteenth maxillary teeth in the larger specimen; the two fenestræ do not correspond with the teeth equally, perhaps the teeth do not correspond with the fenestræ equally on the opposite sides of the larger skull.

INTERNAL NARIAL APERTURE.—This cavity is of moderate size, and is not far from round; in the smaller skull it is slightly longer than broad.

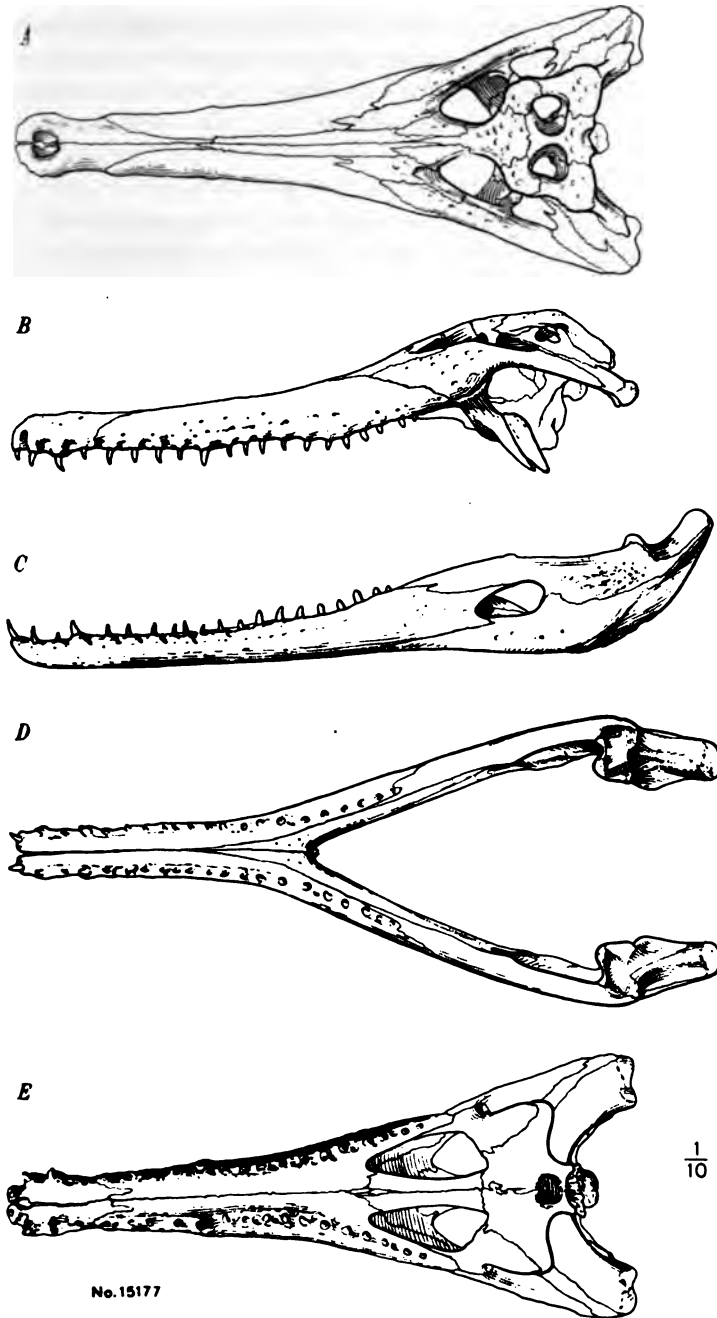


Fig. 2. Skull and jaws of *Tomistoma schlegelii* Müller. Amer. Mus. No. 15177, one-tenth natural size. A, superior view of skull; B, lateral view of skull, left side; C, lateral view of mandible, left side; D, superior view of mandible; E, inferior view of skull.

In the larger skull it faces downward and slightly forward; in the smaller skull the aperture faces downward and slightly forward, but the roof of the nasal passage slopes backward in such a way that the passage faces slightly backward as well as downward.

The Bones of the Skull

PREMAXILLARIES.—The premaxillaries are long and slender. In the smaller skull they extend back to the level of the sixth maxillary teeth, and in the larger one they extend to the spaces between the fifth and sixth maxillary teeth. Their sutures with the maxillaries become more and more near a longitudinal direction as they leave the borders of the snout. There are thus no sharply defined posterior processes separated off from the main masses of the bones. The median suture of the two premaxillaries with each other anterior to the nasals is long. The amount of lateral expansion of the premaxillaries, external to the narial aperture, is slight. The very deep notches between the first and second premaxillary teeth are clearly visible from above.

On the palate the premaxillo-maxillary suture forms a distinct letter W, the apex of which is directed forward. The posterior extension of the suture is directly opposite the second maxillary teeth in the smaller skull studied, and slightly farther back in the larger one. The apex of the W is opposite the first maxillary teeth in the larger skull, and very slightly farther back in the smaller one.

Each premaxillary has four teeth; this is equally true of both large and small skulls. Boulenger states that the young individuals have five teeth in each premaxillary, and that the second is lost with age, as in some species of *Crocodylus*. The elimination of the second teeth evidently takes place at a very early stage, as in the smaller of the two skulls studied the alveoli of these teeth are almost completely obliterated. The four premaxillary teeth are all widely spaced from each other, and are all situated upon elevated pedestals. Between these pedestals are very deep notches which lodge the mandibular teeth; these notches are very deep vertically, but with the exception of those between the first and second teeth do not excavate the lateral borders of the skull. Of the four premaxillary teeth of each side the third (primitively the fourth) is the largest.

MAXILLARIES.—The maxillaries are long and slender. Their most conspicuous feature is a prominent inrolling of their infero-lateral borders; this inrolling has gone so far that a portion of the external surface of each maxillary, posterior to the fifth maxillary tooth, faces downward and outward; this is especially conspicuous in the older skull.

The contacts of the maxillaries with the premaxillaries have been described above. The sutures with the nasals are relatively short, owing to the short anterior extension of the nasal bones. The sutures with the lacrymals are more complex in outline than in most crocodilians, and resemble somewhat those of *Gavialis*. Each suture leaves the nasal border at the level of the posterior edge of the tenth maxillary tooth in the smaller skull, and of the eleventh in the larger skull, and extends backward and slightly outward for a distance about equal to that between two of the maxillary teeth, then extends almost directly forward to a point a short distance anterior to its origin, and then outward and backward to a point above the space between the thirteenth and fourteenth maxillary teeth, where the maxillary, lacrymal, and jugal bones come in contact. A short posterior process of each maxillary wedges apart two anterior processes of the lacrymal. The suture of each maxillary with the jugal is more or less irregular.

The path of the premaxillo-maxillary suture on the palate has been described above. The maxillo-palatine suture is characteristic in outline; it extends little forward of the level of the anterior ends of the palatine fenestræ. From a point near the anterior end of each fenestra the maxillo-palatine suture extends backward and inward to a point opposite the thirteenth maxillary tooth in the small skull, and the fourteenth in the larger one, then inward and forward to a point opposite its origin. Its path is then slightly different in the two skulls; in the smaller one it continues in the same direction to a point slightly anterior to the twelfth maxillary teeth, and at the median line. The two portions of the suture together make a figure like a letter V. Posterior to the apex of this V, at the median line, the suture between the maxillaries and the palatines gives way to the minute sutures between the maxillaries and the prevomers; in the smaller skull these bones are scarcely distinguishable, but they do interrupt the contacts of the maxillaries and the palatines very slightly. In the larger skull the maxillo-palatine sutures are more complex, due to the arrangement of the prevomers. The sutures extend inward and backward from the anterior ends of the palatine fenestræ as in the smaller skull, then turn similarly forward and inward, and at the level of the anterior ends of the fenestræ turn almost directly inward. On the left side there is no process of the palatine anterior to the fenestra; on the right side a very small process wedges forward between the maxillary and the prevomer.

The contacts with the prevomers are nearly antero-posterior; they meet the median line about at the level of the twelfth maxillary teeth; they are unequally long on the opposite sides of the skull.

In the larger skull it faces downward and slightly forward; in the smaller skull the aperture faces downward and slightly forward, but the roof of the nasal passage slopes backward in such a way that the passage faces slightly backward as well as downward.

The Bones of the Skull

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The contacts with the prevomers are nearly antero-posterior; they meet the median line about at the level of the twelfth maxillary teeth; they are unequally long on the opposite sides of the skull.

Each maxillary contains sixteen teeth. The fifth of these is much greater than any of the others, especially in the larger skull. The first four teeth, and the sixth to the ninth inclusive, are approximately equal in size; they are relatively long and slender, and are sharp-pointed. The teeth from the tenth to the sixteenth, inclusive, are much stouter than the anterior ones, but are not blunt. They increase in size from the tenth to the twelfth, which is only slightly smaller than the fifth, and then decrease to the sixteenth. The anterior five teeth are slightly curved, and point downward. Their convex borders are anterior in position. The teeth between the fifth and the twelfth have a tendency to point inward as well as downward; this is much more conspicuous in the larger skull than in the small one; it is correlated with the inrolling of the external surface of the skull at this level.

The first five teeth in each maxillary stand on prominent pedicles; from the fifth backward the pedicles are present, but are not conspicuously developed. They are separated by pits which lodge the mandibular teeth, as far back as the spaces between the fourteenth and the fifteenth. The mandibular teeth bite between the premaxillary and maxillary teeth, and in line with them. The anterior maxillary teeth are very far apart; back of the great fifth tooth the teeth on each side are situated irregularly closer and closer together, until the sixteenth is rather close to the fifteenth; none of the teeth are very close together.

NASALS.—The nasal bones of this form are very characteristic in outline. They are intermediate in form and position between those of the gavial and those of the true crocodiles. They articulate with the premaxillaries anteriorly as in *Crocodylus*, separating the maxillaries from a median contact with each other on the surface of the snout, such as is present in *Gavialis*. They differ from those of the true crocodiles, however, in being widely separated from the external narial aperture.

Their anterior extremities, along the median line, are above the spaces between the fourth and fifth maxillary teeth. The posterior ends of the premaxillo-nasal sutures are at the level of the fifth maxillary teeth in the smaller specimen, and slightly farther back in the larger one. The sutures with the maxillaries are relatively short; those with the lacrymals are relatively long; those with the prefrontals are shorter than those with the lacrymals, and are very irregular in outline.

From their anterior extremities backward the nasals broaden with only slight irregularities to the level of the tenth or eleventh maxillary teeth, where the bones reach their maximum breadth; from this point back, they retain this breadth, the lateral borders being parallel, to the

In form the palatine bones are very slender, although they have very slight anterior and posterior lateral expansions.

PREVOMERS.—These bones appear at the surface of the palate; the species therefore differs from all other Recent crocodilians except *Caiman niger*. In the latter species, however, the prevomers appear at the anterior end of the palate, along the boundaries of the maxillaries and premaxillaries, and not back near the palatines. In *Tomistoma schlegelii* they are situated posterior to the median portions of the maxillaries. In the smaller of the skulls studied they appear as thin slivers of bone, which separate the anterior ends of the palatines from each other; in the larger skull they partly replace the anterior processes of the palatines. Posterior to them is a median bone, also separating the palatines, which may be related to them in composition.

PTERYGOIDS.—The sutures of the pterygoids with the ectopterygoids converge sharply forward; they are irregular in outline. The median suture of the two pterygoids with each other along the palatal surface is exceedingly irregular. Each pterygoid forms a very small portion of the posterior border of the palatine fenestra. The posterior processes of the pterygoids are very large. The internal narial aperture is situated only partly on the general palatal surface, part of it being situated on a posterior extension of the bone, back of the level of its principal posterior border; the posterior processes extend back from this and partly embrace the basisphenoid. The notch at the posterior end of the pterygoids is horizontal only, not vertical also, as in most crocodiles.

ECTOPTERYGOIDS.—The anterior processes of the ectopterygoids are unusually small, both in length and thickness. The postero-inferior processes are large and thick, and the superior processes medium in size.

The Mandible

The mandible of this species is distinctly intermediate in form and structure between the gavial and the true crocodiles. In general form it corresponds with the snout, being long and slender, and spreading rather abruptly at a point about one-third of its total length back from its anterior end. The symphysis is very long, extending back to the level of the fifteenth teeth; it is not as long as in the gavial, however. The splenial bones are very long, and together form a conspicuous portion of the posterior portion of the symphysis. They vary in their anterior extent on the opposite sides of both of the specimens studied; their anterior processes end at the ninth or tenth teeth. Their anterior symphyseal portions are much shorter than their posterior portions. The

PARIETAL.—The parietal is nearly as broad at its posterior as at its anterior end. Its median bar, between the two supratemporal fenestrae, is long and slender. Along its posterior border the parietal is deeply indented, both vertically and horizontally; this is especially true in the older skull. The surface of the posterior plate of the bone is slightly concave.

SUPRAOCCIPITAL.—The supraoccipital comprises no part of the face of the cranial table, but a small portion of it occupies the floor of the small cirque-like depression at the center of the postero-superior border of the skull. This floor is much broader than it is long.

On the posterior surface of the skull the supraoccipital extends downward about two-thirds of the distance from the posterior border of the cranial table to the foramen magnum; laterally its breadth is slightly greater than one-third of the breadth of the cranial table.

EXOCCIPITALS, BASIOCCIPITAL, AND BASISPHENOID.—These bones possess no characters which differ sufficiently from those of other Reptilian crocodilians to require special description.

QUADRATES.—The quadrates are characterized only by the regular sutures with the quadrato-jugals.

QUADRATO-JUGALS.—The sutures of the quadrato-jugals with the quadrates are exceedingly irregular; in their outlines they approach the condition of the gavial rather than that of the true crocodiles. The quadrato-jugal possesses a sharp anterior process, which is intermediate between those of the true crocodiles and those of the gavial, but is closer to the former than to the latter. This process is long and slender, it rises from the anterior edge of the bone, and not from its external face as in the gavial; its lower border is not, however, a direct anterior superior continuation of the contact of the quadrato-jugal with the jugal, but is separated from this border by an antero-inferior process of the bone. Each quadrato-jugal therefore forms a very small portion of the inferior border of the infratemporal fenestra, as well as its posterior border.

JUGALS.—The jugals are rather large; in general form they appear to be unusually long and slender, but each has a rather prominent superior process near the anterior end of the orbit; this process tends to constrict the posterior end of the orbit.

PALATINES.—The sutural connection of the palatines with the maxillaries has been described above. The palatines are slightly separated from each other at their anterior ends by the slender prevomers, which appear at the surface of the palate. The suture of the palatines with the pterygoids is irregularly transverse.

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ECTOPTERYGOIDS.—The anterior processes of the ectopterygoids are unusually small, both in length and thickness. The postero-inferior processes are large and thick, and the superior processes medium in size.

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mandible is very low vertically in its anterior portion, but is rather high posteriorly. The external mandibular foramen on each side is elongate; above it the surangular bone has a slight process on its superior border, extending inward and slightly upward.

Each ramus of the mandible contains twenty teeth. These are all rather far apart, and their intervening spaces are practically equal. There is a slight variation from this, however: from the first to the seventh or eighth they are rather far apart, the second and third being considerably so; the eighth and ninth are closer together; posterior to the ninth the teeth are all moderately far apart. The first tooth in each mandible is the longest; the fourth is second in size; the thirteenth or the fourteenth is also large. The teeth between the fourth and the thirteenth are small. In the larger specimen the teeth posterior to the fourteenth are rather large, but in the smaller specimen they are small; this difference is probably due to variations in the stages of development of the individual teeth. The anterior teeth are very slender and sharp; the posterior ones are stouter, but are still rather sharp. The larger teeth are rooted in pedicles, and all of the teeth are separated from each other by deep pits. Those of the posterior end of the series are directed slightly inward, as in the upper jaws, and the external surfaces of the mandible face slightly upward as well as outward. The upper and lower jaws together, therefore, are somewhat indented along the posterior portions of the dental borders.

Measurements

	Amer. Mus. No. 15177	Mus. Comp. Zool. No. 12459
Length of Skull, Tip of Snout to Supraoccipital	.765M.	.537M.
Length of Skull, Tip of Snout to Ends of Quadrates	.842	.586
Length of Snout	.577	.400
Breadth of Snout at Base	.204	.100
Breadth of Cranial Table	.188	.118
Breadth of Skull Across Quadrato-jugals	.352	.212
Breadth of Interorbital Space	.040	.023
Breadth of Space Between Supratemporal Fenestræ	.017	.010
Length of Mandible, Total	.935	.650
Length of Symphysis	.410	.310
Breadth of Mandible, Total	.372	.213

Remarks

In many respects this species is intermediate in character between the gavial, on the one hand, and the true crocodiles on the other. In the totality of its characters, however, the resemblance to the true croc-

diles is considerably the greater; the resemblances to the gavial may be largely explained as similar adaptations to corresponding modes of living.

CROCODYLUS Laurenti

GENERIC CHARACTERS

This genus includes a large proportion of the species of the living crocodiles. All of the living species, and many fossil ones as well, have seventeen to nineteen teeth in the upper jaw, and fifteen only in the lower; the fifth maxillary tooth is always enlarged. Typically the fourth mandibular tooth, on each side, fits into a notch in the upper jaw, along the lateral component of the premaxillo-maxillary suture; in some of the broader snouted species, however, this character varies somewhat, the fourth mandibular tooth biting into a pit as in the alligators. It is very probable that this condition varies to some extent with the age of the individual. The sides of the snout are prominently festooned vertically. The nasal bones usually reach and enter the narial aperture, but occasionally fall short of it. The quadrato-jugals always have sharp anterior processes which enter the infratemporal fenestræ. The supratemporal fenestræ are small and are usually close together. The cranial table is usually of moderate size; it varies considerably in size; a small bony plate is usually present in each upper eyelid. The mandibular symphysis is relatively short, not extending back of the eighth teeth in any species, and usually not back of the fifth; the splenial bones form no part of the symphysis.

This genus, which is variable in form at the present time, and appears to have been in the past, is evidently near the central line from which most of the existing crocodilians have sprung.

Crocodylus americanus Laurenti

This description of the skull of *Crocodylus americanus* is based upon studies of a large series of skulls of this species. The material which comprised the principal source of information includes three very young skulls in the collections of the Museum of Comparative Zoology (Mus. Comp. Zool. Nos. 5002, 5007, and 5008, two somewhat older specimens, Amer. Mus. No. 15182) and (Mus. Comp. Zool. No. 5032), four half-grown skulls in the American Museum collections (Amer. Mus. Nos. 5175, 7120, 7132, and 7121), and a huge old skull in the American Museum (Amer. Mus. No. 7139); in addition to these three other skulls, one half grown, one more than half grown (Mus. Comp. Zool. Nos. 391, 10921), and the other large, were used for verification of these characters.

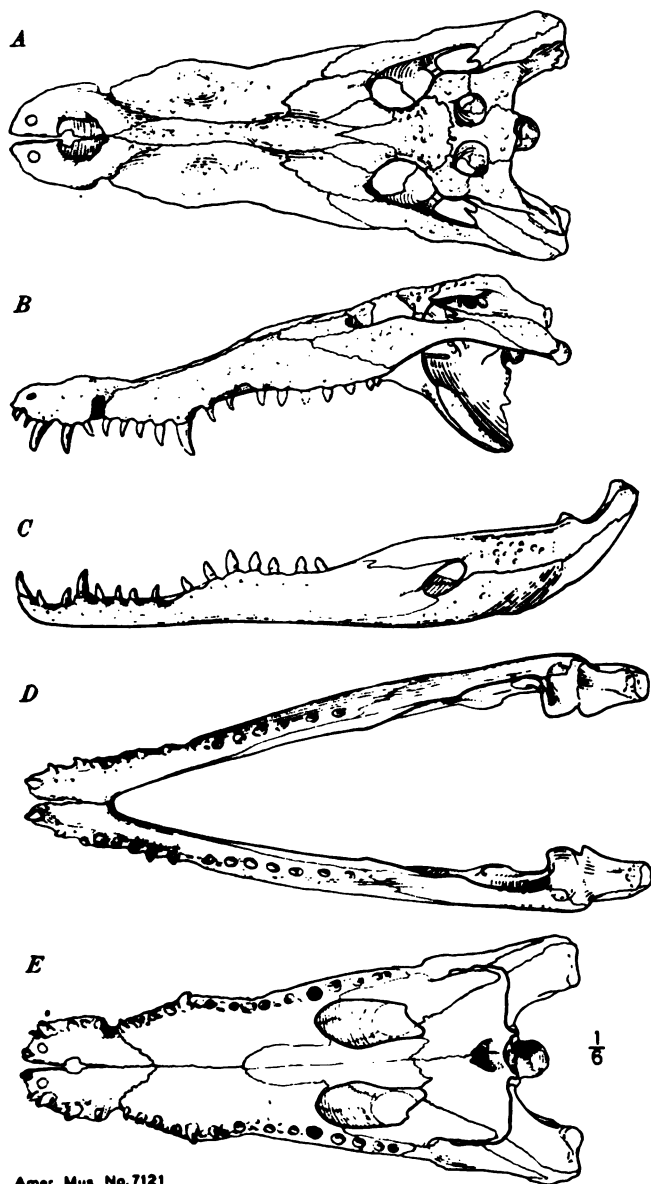
General Form

The skull of *Crocodylus americanus* is usually identifiable from its form alone. The form is variable, however, and grades toward the form of the skull of *C. niloticus*. The cranial table is relatively small, and is not concave, even in old individuals. Its straight lateral borders converge slightly in the anterior direction, and the antero-external angles are rather sharp. The snout is usually long and slender; occasionally this character is not emphasized, two skulls studied having the snout relatively stout (Amer. Mus. No. 7121 and Mus. Comp. Zool. No. 10921). Boulenger states that the snout ranges from once and three-fifths to twice and one-fourth as long as broad at the base; in one of the skulls studied (Amer. Mus. No. 7139) the snout is about two and one-half times as long as broad at the base. A characteristic feature of the snout of this species is a median elevation a short distance in front of the orbits. This is absent in the very young individuals, but appears in an inconspicuous manner in a 11.6 cm. specimen (Mus. Comp. Zool. No. 5007). From this size up to the maximum in the series studied the elevation is prominent in most of the specimens. In a few, such as Amer. Mus. No. 7121 and Mus. Comp. Zool. No. 10921, it is not conspicuous; these skulls, however, differ somewhat from typical *C. americanus* skulls in a number of respects; one of them is a Cuban specimen, and it is quite likely that the other has come from a different locality than the larger part of the series, consequently the differences may be ascribed to geographic variation. This median elevation is unknown in other modern species of *Crocodylus*, and when typically developed makes the species easily recognizable. The elevation is composed of the greater part of portions of the nasal bones, but the surrounding bones, maxillaries, lacrymals, and prefrontals, also enter into it.

The lateral "canine" constriction is very deep, except in very young individuals, and the constriction posterior to the seventh maxillary teeth is rather deep. The vertical festooning is prominent in both upper and lower jaws. The teeth of the upper jaw frequently excavates conspicuous grooves on the margins of the lower jaw.

The Cavities of the Skull

SUPRATEMPORAL FENESTRÆ.—These fenestræ are relatively small and close together. Except in the very young skulls they are nearly circular; in the latter they are oval. In the very young skulls they are larger than the external narial aperture; in the half-grown and adult skulls they are smaller.



Amer. Mus. No. 7121

fig. 3. Skull and jaws of *Crocodilus americanus* Laurenti. Amer. Mus. No. 7121, one-sixth life size. A, superior view of skull; B, lateral view of skull, left side; C, lateral view of mandible, left; D, superior view of mandible, left side; E, inferior view of skull.

INFRATEMPORAL FENESTRÆ.—These fenestræ have the usual crocodilian subtriangular outline and partial division into two portions by the quadrato-jugal processes. They are slightly larger than the supratemporal fenestræ.

ORBITS.—The orbits are very large in the younger specimens and relatively smaller in the older ones. They are round in outline, and slightly longer than broad; they are moderately far apart.

EXTERNAL NARIAL APERTURE.—This cavity is moderately large and is nearly circular in outline. It is usually penetrated by the anterior processes of the nasal bones.

PREMAXILLARY FORAMEN.—The premaxillary foramen is small; is heart-shaped in outline, and its lateral diameter nearly equals its length.

PALATINE FENESTRÆ.—The palatine fenestræ extend forward as far as the tenth maxillary teeth. Their sides are nearly parallel, and the anterior ends are rounded. Their posterior ends vary from broad rounded to pointed.

INTERNAL NARIAL APERTURE.—The internal narial aperture partly divided by a median bony septum. It opens obliquely backward and downward.

The Bones of the Skull

PREMAXILLARIES.—The premaxillaries are of moderate length. They never extend back of the fourth maxillary teeth, and usually not behind the third. They are sometimes slightly elevated around the narial aperture, and are frequently crossed, posterior to the narial aperture and anterior to the premaxillo-maxillary sutures, by a pair of low oblique ridges. The pits which lodge the first mandibular teeth usually penetrate through the superior plate of the premaxillaries.

On the palate the premaxillo-maxillary suture is variable in form. In some skulls it is V-shaped, in others it is W-shaped. In one skull (Amer. Mus. No. 7121) it extends back behind the level of the third maxillary teeth; in other skulls it does not extend back beyond the level of the second maxillary teeth. Each premaxillary contains five teeth, the second of which is small, as in most species of *Crocodylus* which possess five premaxillary teeth. The first and second are widely spaced apart, the second and third are close together, while the third and fourth, and the fourth and fifth are moderately far apart. The great pits, or foramina, which lodged the first mandibular teeth are situated slightly internal to the first and second premaxillary teeth, rather than in direct line with them. The pits which lodged the second and third mandibular

teeth are situated between the third and fourth, and fourth and fifth premaxillary teeth respectively, and not internal to them. In Amer. Mus. No. 7120 and No. 3070 the premaxillary teeth extend obliquely downward and forward.

MAXILLARIES.—The maxillaries are long and slender; they narrow slightly immediately posterior to the seventh maxillary tooth. They are elevated into prominent tuberosities over the spaces between the fifth and sixth maxillary teeth; these tuberosities lodge the elongated roots of the great fifth maxillary teeth. In the youngest specimen in the collections studied (Mus. Comp. Zool. No. 5002) they are nearer the orbits than the narial aperture; in the oldest specimen (Amer. Mus. No. 7139) they are situated about twice as far from the orbits as from the narial aperture. The intervening specimens have these tuberosities in intermediate positions.

On the palate the maxillaries are not very distinctive. The maxillo-palatine sutures extend inward and backward from the anterior ends of the palatine fenestræ, then turn sharply forward and meet at the median line opposite the seventh maxillary teeth. This suture varies considerably in form. In some skulls it extends forward as a straight line on each side, then turns abruptly and meets its opposite in an almost transverse direction at the level mentioned above; in other cases it curves gradually forward and inward, meeting its opposite in a rather sharp point. There are typically fourteen teeth in each maxillary, but one specimen (Amer. Mus. No. 7132) has only thirteen, and another (Amer. Mus. No. 7120) has thirteen on the right side and fourteen on the left. The teeth are all situated moderately far apart from each other, and are separated by pits, or in some cases, grooves, which lodge the mandibular teeth; these pits or grooves are all in line with the teeth, and not internal to them. The anterior teeth are long-crowned, sharp-pointed, and curved; the posterior ones are shorter-crowned, less sharp, and nearly straight; there is a gradation between the two conditions. Although the posterior teeth are not so sharp as those in the anterior portions of the maxillaries, they are not blunt as in some crocodilians, such as *Caiman sclerops*. The maxillary teeth increase regularly in size from the first to the fifth, then decrease more or less irregularly to the fourteenth.

NASALS.—The nasals are relatively narrow, except for a short distance not far forward of the orbits, in which distance they are expanded. This expansion extends along the area occupied by the median elevation of the snout; it reaches a maximum breadth slightly anterior to the level of the ninth maxillary teeth. At the posterior end the nasals are wedged

apart by the relatively broad anterior process of the frontal. At the anterior ends the nasals project into the narial aperture at the surface; in some specimens, in others they are covered by the premaxillaries at the surface, but enter the aperture at a lower level.

LACRYMALS.—In the younger specimens the lacrymals approximately equal the prefrontals in surface area; in the older ones the lacrymals are considerably larger than the prefrontals. In both young and old individuals the sutures with the nasals are very short. In form the bones are irregular, and are not especially characteristic.

PREFRONTALS.—As noted above, the prefrontals equal the lacrymals in size in the younger specimens, but are much smaller in the older ones. Their sutures with the nasals are longer than the naso-lacrymal sutures in both young and old specimens. The prefrontals differ slightly from those of *Crocodylus niloticus* in that their lateral borders have opposite curves, both internal and external sides of the bones being convex, contrasting with the concave external borders and convex internal borders in the latter species.

FRONTAL.—The frontal bone is of moderate size, and is not especially characteristic in outline. Its anterior process equals in length its posterior plate. Its anterior wedge, between the posterior ends of the nasals, is short and broad.

POSTORBITALS.—These bones are of medium size; they are relatively long and narrow. They compose very small portions of the anterior walls of the supratemporal fenestræ.

SQUAMOSALS.—In the youngest specimen examined (Mus. Comp. Zool. No. 5002) the external and posterior borders of the squamosals are elevated into distinct ridges; these are lost in the remainder of the series. Each squamosal occupies about one-third of the posterior border of the cranial table.

PARIETAL.—The parietal bone occupies a considerable space anterior to, as well as between and posterior to, the supratemporal fenestræ. The supraoccipital enters the posterior portion of the parietal as a wedge in the younger specimens, but this wedge becomes progressively reduced with age, until in the oldest specimen (Amer. Mus. No. 7139) the parietal occupies the entire posterior border of the cranial table.

SUPRAOCCIPITAL.—As noted above, the supraoccipital occupies a small wedge-shaped area on the surface of the cranial table in the younger specimens. This wedge is comparatively long and narrow. With age it rapidly decreases in size, until in a half-grown individual it is scarcely visible from above; in the great adult specimen (Amer. Mus. No. 7139) it is absent from the cranial table altogether.

On the posterior aspect of the skull the supraoccipital occupies a large triangular-shaped area, which in the very young specimens extends downward nearly to the foramen magnum. This position, or extent, is retained until the skulls are about half-grown. At this stage the supraoccipitals in some of the skulls extend nearly to the foramen magnum, and in others they extend only about two-thirds of the distance down from the superior border. In Amer. Mus. No. 7139 it extends scarcely two-thirds of the distance down from the superior border to the foramen magnum.

QUADRATO-JUGALS.—The quadrato-jugals are characteristic only in that the anterior processes which project into the infratemporal fenestræ are very sharp, but are not long.

QUADRATES, EXOCCIPITALS, BASIOCCIPITAL, AND BASISPHENOID.—These bones are not characteristic in form.

JUGALS.—The jugal bones are of moderate length, and are neither thick nor thin. In the younger individuals they extend as far forward as the seventh or eighth maxillary teeth; in the older specimens they are situated progressively farther and farther back, until in the oldest specimens (Amer. Mus. No. 7139) they do not reach the level of the tenth maxillary teeth.

PALATINES.—The sutures of the palatines with the maxillaries have been described in discussing the latter bones. The suture with the pterygoids is somewhat variable in direction, at the same time having certain elements in common in all the specimens. In none of the specimens is it directly transverse. Typically it extends backward and inward on each side from a point near but not at the posterior end of the palatine fenestra, then irregularly inward across the median line, and in a similar direction on the opposite side. The external portions are constant in direction, but the inner portion is somewhat variable. In one specimen (Amer. Mus. No. 7121) this inner portion takes the form of a V, with the apex directed forward; in several other specimens it forms a very broad V; in still others it is irregularly curved.

The palatines are constricted somewhat about three-fifths of their length back from their anterior ends. This constriction is slight in the younger skulls, but is more pronounced in most of the older ones, and is very marked in Amer. Mus. No. 7139. In one half-grown skull (Amer. Mus. No. 15175) it is scarcely noticeable.

PTERYGOIDS.—The pterygoids occupy small but appreciable portions of the posterior ends of the palatine fenestræ. They are

	Mus. Comp. Zool.		Amer. Mus.	Mus. Comp. Zool.	Amer. Mus.		
	No. 5002	No. 5008	No. 5007	No. 15182	No. 15175	No. 7120	No. 7121 No. 7132 No. 7139
Length of Skull, Tip of Snout to Supra- occipital	.063M.	.088M.	.116M.	.193M.		.379M.	
Length of Skull, Tip of Snout to Ends of Quadrates	.061	.090	.120	.205	.337	.416	.443 .793
Length of Snout	.033	.052	.071	.126	.206	.256	.280 .534
Breadth of Skull, Across Quadrato- jugals	.027	.039	.050	.084	.149	.1935	.200 .368
Breadth of Cranial Table	.0212	.027	.033	.050	.084	.115	.123 .1155 .1815
Breadth of Snout at Base	.021	.027	.035	.057	.110	.115	.135 .146 .231
Breadth of Snout, Across Fifth Maxil- lary Teeth	.016	.021	.027	.045	.082	.086	.099 .120 .185
Length of Mandible	.088	.101	.135	.221	....	.473	493 .895
Breadth of Mandible, Maximum	.026	.041	.051	.088	....	.192	227 .380

moderately long in proportion to their breadth, and their lateral borders, or sutures with the ectopterygoids, converge sharply in the anterior direction.

ECTOPTERYGOIDS.—These bones are not especially characteristic in form or proportions; the three processes of each are not far from being equal in size, though the superior process is somewhat smaller than the other two, and the anterior process is more slender than the inferior one. The ectopterygoids extend as far forward as the eleventh maxillary teeth, or as the spaces between the eleventh and twelfth maxillary teeth.

Mandible

The mandible of this species contains the usual crocodilian number of fifteen teeth in each ramus. These are more or less unevenly spaced, and are often separated by grooves which lodged the superior teeth. The anterior eight or nine teeth are slender, while the posterior six or seven are broader in the antero-posterior direction, but are not blunt. In the older individuals several of the teeth rise from elevated pedestals. The anterior teeth extend outward as well as upward in some of the specimens, corresponding to the oblique position of some of the teeth in the upper jaws.

Crocodilus cataphractus Cuvier

The description of this species is based upon a sixteen inch skull in the American Museum Collections (Amer. Mus. No. 10075).

General Form

The skull of this species is exceedingly long and slender. In its general appearance it resembles the skull of *Tomistoma schlegelii*. The snout is especially long and slender. Boulenger states that it is twice and two-thirds to thrice and one-third as long as broad at the base. It is considerably expanded at its anterior end, and slightly expanded at the fifth maxillary teeth. The surface of the snout is low and relatively smooth.

The cranial table is small, especially in the lateral direction. It is flat, and its posterior border is formed of a double curve, the supra-occipital region extending outward as a short process and interrupting the concave border of the table. The lateral borders of the table are nearly parallel, but converge very slightly in the anterior direction. The antero-external angles of the table are rounded.

The Cavities of the Skull

SUPRATEMPORAL FENESTRÆ.—These cavities are of medium size, and are rather close together. Each of them is about equal to the narial aperture in size. In comparison with the small size of the cranial table the cavities are large. They are irregularly subcircular in outline; their axes of maximum diameter converge posteriorly.

INFRATEMPORAL FENESTRÆ.—The infratemporal fenestræ are small. They are subtriangular in outline, and are partially divided into superior and inferior portions by the sharp process of the quadrato-jugals, which is unusually large.

ORBITS.—The orbits are moderately large; their antero-posterior diameters are considerably greater than their transverse. They are situated a moderate distance apart from each other.

EXTERNAL NARIAL APERTURE.—The narial aperture is subtriangular in outline; the apex of the triangle is at the posterior end, and the curved base at the anterior end. The antero-posterior diameter is greater than the transverse. The nasal bones do not reach the cavity, but the premaxillaries send forward a very short median process into it; this process does not reach the superior surface of the skull, but extends into the aperture at a deeper level only.

PREMAXILLARY FORAMEN.—This cavity is heart-shaped and is small in size; its transverse diameter is as great as its length.

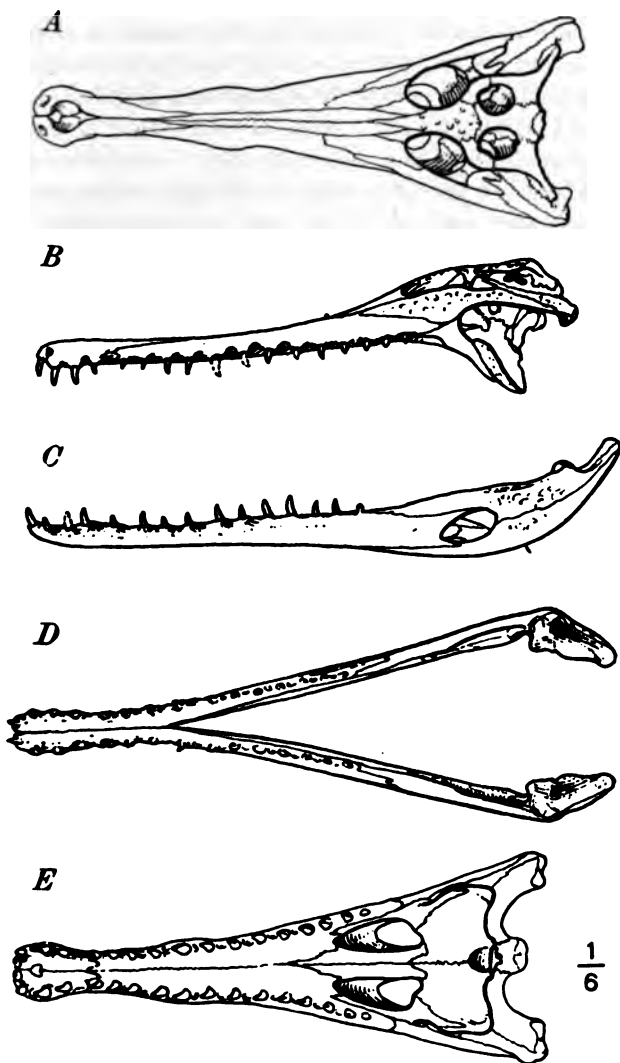
PALATINE FENESTRÆ.—The palatine fenestræ are long and narrow. Their anterior ends are sharp; the internal borders are concave, while the external borders are nearly straight lines; the external borders turn inward sharply near their posterior ends, and merge into the posterior borders, which are oblique in position. The fenestræ extend as far forward as the eleventh maxillary teeth. They differ from those of most crocodilians in extending farther back beyond the teeth than they do forward along side of the teeth.

INTERNAL NARIAL APERTURE.—This opening is relatively small.

It is directed sharply backward as in *C. porosus* and not downward as in most crocodilians.

The Bones of the Skull

PREMAXILLARIES.—The premaxillaries are characteristic in form. Their anterior portions are expanded considerably, especially near the anterior ends of the narial cavity. At the "canine" notches the bones are somewhat constricted. The posterior processes are long and slender; they extend back as far as the level of the fourth maxillary teeth. Pos-



Amer. Mus. No. 10075

Fig. 4. Skull and jaws of *Crocodilus cataphractus* Cuvier. Amer. Mus. No. 10075, one-sixth natural size. A, superior view of skull; B, lateral view of skull, left side; C, lateral view of mandible, left side; D, superior view of mandible; E, inferior view of skull.

terior to the narial aperture the two premaxillaries meet each other along the median line, excluding the nasals from the aperture.

The premaxillo-maxillary suture on the palate is irregularly shaped; it does not extend back beyond the level of the second maxillary teeth, and the median apex of the W does not extend forward beyond level of the first maxillary teeth. There are four teeth in each premaxillary, the second tooth of the more primitive crocodiles not being presented. The teeth are all far apart, and are about equally spaced. The pits which lodge the mandibular teeth are conspicuous, and are in line with the teeth themselves, and not internal to them. The pits which lodge the first mandibular teeth have pierced the surface of the skull opening up two large foramina. The first premaxillary teeth are absent in the specimen, but their alveoli indicate that they are the smallest teeth in these bones. The second teeth are the largest, the third are second size, and the fourth not much larger than the first.

MAXILLARIES.—The maxillary bones are long and narrow. Their sutures with the premaxillaries, nasals, and ectopterygoids are very long and their sutures with the lacrymals and jugals moderately long.

On the palate their sutures with the palatines are peculiar. Their sutures extend inward and slightly backward from the anterior end of the palatine fenestræ, for a very short distance, and then inward and forward in irregular lines to the median line, where they meet opposite the ninth maxillary teeth. These sutures converge sharply, and have suggestion of the more or less parallel arrangement observable in many crocodiles. The ectopterygoids extend so far forward that the maxillaries have only a very small place in the external borders of the palatine fenestræ. The suture with the premaxillaries has been described above.

There are only thirteen teeth in each maxillary. These teeth are more or less evenly spaced, and are all far apart. They are separated from each other by spaces which contain pits for lodgment of the mandibular teeth, except posterior to the eleventh, where the pits die out. The teeth themselves, especially the larger ones, appear to be elevated on small pedicles. The palatine surface of the maxillaries is decidedly convex in the transverse direction, and in consequence the teeth extend outward, somewhat as they do in *Tomistoma schlegelii*. The teeth increase in size in the maxillaries, regularly from the first to the fifth, then decrease. The anterior eight or ten maxillary teeth are very sharp and slender, the posterior teeth have relatively short crowns, and are not so sharp as those farther forward in the mouth. None of the maxillary teeth, however, are very blunt. Each maxillary extends backward a considerable distance beyond the last maxillary tooth.

NASALS.—The nasals are exceedingly long and slender. Posteriorly they are wedged apart by a short process of the frontal; a short distance anterior to this point they expand considerably in breadth, reaching their maximum breadth at the level of the ninth or tenth maxillary teeth. Anterior to this they become gradually more and more constricted, and finally disappear from the surface of the skull as very slender processes at the level of the second maxillary teeth. The sutures of the nasals with the lacrymals and prefrontals are both relatively long, and the former is about two-thirds as long as the latter.

LACRYMALS.—The lacrymal bones in this species are long and slender. They occupy about three times as much space upon the superior surface of the skull as the prefrontals, and portions of the orbital borders equal in extent to the prefrontal portions. They extend as far forward as the level of the ninth maxillary teeth.

PREFRONTALS.—The prefrontals are small; their internal and external borders converge anteriorly, so that the bones terminate in sharp points. Posteriorly they are rather broad.

FRONTAL.—This bone is relatively short antero-posteriorly in proportion to its breadth, as compared with the prefrontals and lacrymals. The anterior process does not extend very far forward between the nasals.

POSTORBITALS.—The postorbital bones are very small; they occupy perhaps one-third as much area as that occupied by the squamosals. The pits on them are large.

SQUAMOSALS.—The squamosals are large; they are smooth near their contacts with the parietals, but are deeply pitted elsewhere on the cranial table.

PARIETAL.—The parietal is relatively narrow. It occupies only a very small portion of the posterior border of the cranial table, owing to the considerable breadth of the supraoccipital; the pitting of the bone is somewhat different from that of the surrounding bones, having only a very few large, widely spaced pits.

SUPRAOCCIPITAL.—This bone is characteristic in form. On the cranial table its antero-posterior extent is very slight, but its lateral extent is considerable; consequently it occupies a large portion (nearly three-fourths) of the border of the cranial table between the two squamosals. On the posterior surface of the skull it extends downward about two-thirds of the distance from the superior border to the foramen magnum.

QUADRATO-JUGALS.—These bones are characterized by their parallel lateral borders.

EXOCCIPITAL, BASIOCCIPITAL, BASISPHENOID, AND QUADRATES.—These bones are not sufficiently characteristic of the species to warrant special description.

JUGALS.—The jugals are relatively long and slender, their length being over five and one-half times their greatest height.

PALATINES.—The palatines are characteristic. Their sutures with the maxillaries have been described above. Their sutures with the pterygoids extend inward and very slightly backward for about half the distance from the palatine fenestræ to the median line, then turn forward at angles of approximately 45° and meet on the mid-line opposite the ninth maxillary teeth, roughly paralleling the maxillo-palatine sutures in direction. The palatines assist the pterygoids in enclosing an enlargement of the nasal passage somewhat similar to that of *Crocodylus porosus*.

PTERYGOIDS.—These bones are only slightly concave on their palatal surfaces. As noted above, the pterygoids and palatines enclose an enlargement of the nasal passage.

ECTOPTERYGOIDS.—The ectopterygoids of *C. cataphractus* are characteristic. Their inferior processes are relatively stout, except at their distal ends, where they taper to points; their anterior processes are unusually long and slender; the superior processes are both short and slender.

Mandible

The mandible is long and narrow like the skull; it is also low vertically, and the bones of which it is composed are individually slender. The symphysis is long, extending back beyond the seventh mandibular teeth. The splenial bones extend forward to the symphysis, but do not form a part of it.

The teeth correspond in form with those of the upper jaw, for the most part being slender and sharp-pointed; they are all separated a considerable distance from each other; these distances are approximately equal, except for the spaces between the eighth and ninth teeth, which are greater than the rest. Between most of the anterior mandibular teeth the jaw is excavated into notches for the reception of the maxillary and premaxillary teeth; posterior to the ninth teeth these notches are replaced by pits, which are situated between the teeth, and in line with them, to the end of the dental series. The number of the mandibular teeth is fifteen in each ramus, as in other species of *Crocodylus*.

The posterior processes of the mandible turn in sharply toward each other more than in most crocodilians. The nearest approach in this character is not in *Tomistoma*, or other long-snouted forms, but in *Crocodylus rhombifer*.

Measurements Amer. Mus. No. 10075

Length of Skull, Tip of Snout to Supraoccipital	.393M.
Length of Skull, Tip of Snout to Ends of Quadrates	.423
Length of Snout	.293
Breadth of Skull Across Quadrato-jugals	.162
Breadth of Cranial Table	.085
Breadth of Snout at Base	.085
Breadth of Snout Across Fifth Maxillary Teeth	.045
Length of Mandible	.470
Breadth of Mandible, Maximum	.162

Crocodylus intermedius Graves

The following description of the skull of this species is based upon a single specimen, about twelve and one-half centimeters long, in the American Museum Collections (Amer. Mus. No. 8790). This is evidently a rather young specimen.

General Form

The skull is long and slender, and in many respects resembles that of *C. cataphractus*. The snout is between twice and one-half and thrice as long as broad at the base; it is very low in transverse profile. Its anterior end, surrounding the external narial aperture, is expanded laterally. The constriction between the premaxillaries and maxillaries is slight, and that in the region of the sixth maxillary teeth is scarcely noticeable; the vertical festooning is also slight; the slight development of these constrictions and loops may be partly due to the immature age of the specimen, as well as being a characteristic of the species. The superior antero-posterior profile of the snout is slightly concave; this also may be partly an age character.

The cranial table is flat; its posterior border is slightly concave; its lateral borders are very nearly straight, and differ from the corresponding borders in most crocodilians in converging slightly in the posterior direction; this also may be associated with the young age of the individual. The antero-external angles are rounded. The relatively great breadth of the cranial table compared with the total breadth of the skull is another character which may be correlated with the young stage of the specimen.

The Cavities of the Skull

SUPRATEMPORAL FENESTRÆ.—The supratemporal fenestræ of the specimen described are elongate in outline, which is a character indicating youth; their comparatively great distance from each other is also largely due to the youthful condition of the specimen; the fenestræ are pointed

at their anterior ends, and their longitudinal axes make sharp angles with the longitudinal axis of the skull, the axes of the fenestra converge sharply in the posterior direction. Each fenestra occupies a slightly greater area than the external narial aperture.

INFRATEMPORAL FENESTRÆ.—These fenestræ are sharply triangular in outline, their borders being straight and not curved; their posterior borders are only slightly interrupted by the anterior processes of the quadrato-jugals.

ORBITS.—The orbits are large in size, and are close together, most young crocodilians. They are irregularly rounded in outline, are slightly pointed at their anterior ends; their longitudinal diameters are somewhat greater than their transverse, and converge very slightly in the anterior direction.

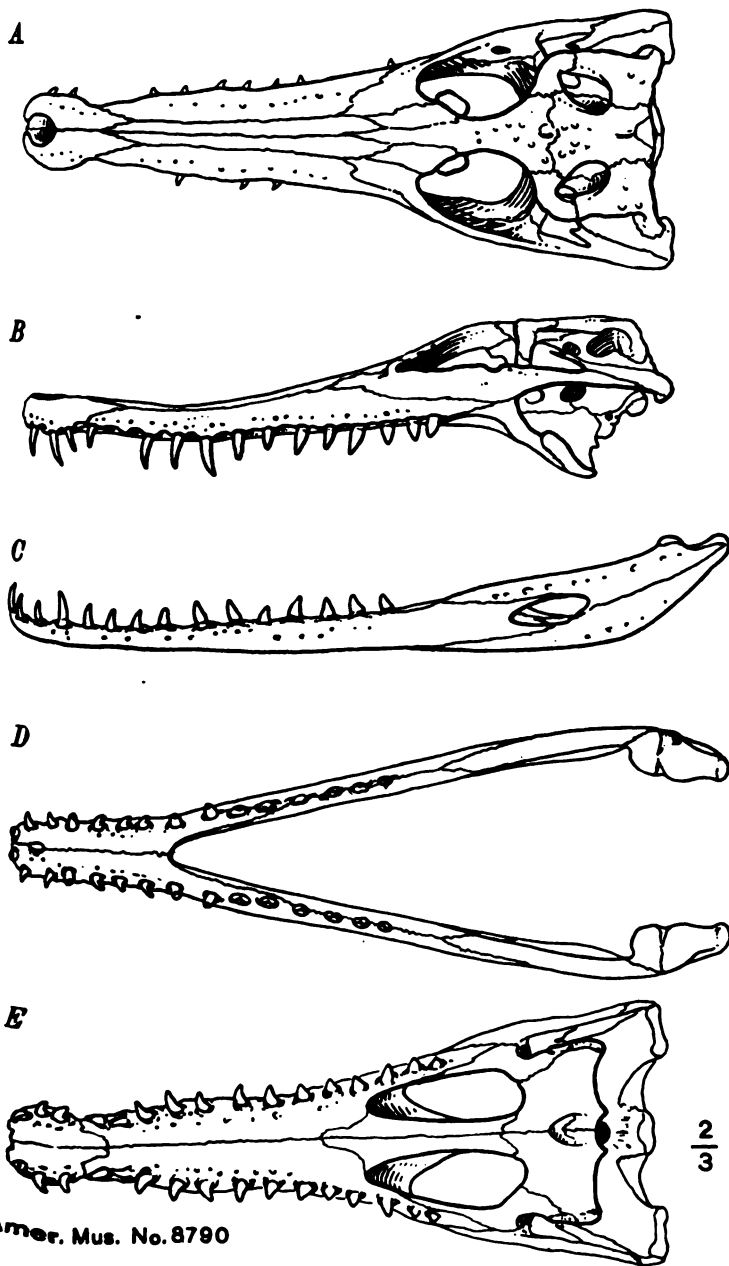
EXTERNAL NARIAL APERTURE.—This cavity is not complete in the specimen, its anterior border having been partially destroyed in preparation. It is clear, however, that the length of the cavity is slightly greater than its breadth; it has no median process at its posterior end, the nasal bones being widely separated from it by the premaxilla. The cavity is slightly pointed at its posterior end; this end is situated anterior to the level of the fourth premaxillary teeth.

PREMAXILLARY FORAMEN.—The premaxillary foramen is extremely small, being about two millimeters in length, and considerably less in breadth. It is situated between the second premaxillary teeth.

PALATINE FENESTRÆ.—These cavities are of moderate size. Their external and internal borders are concave, and converge in the anterior direction; their anterior ends are neither distinctly pointed nor rounded but are somewhat intermediate in condition; the right fenestra is narrow and acuminate, but the left one is very slightly rounded. Their external borders merge into the postero-external ones; the posterior ends are broadly rounded. The right fenestra extends as far forward as the tenth maxillary tooth, while the left one only extends to the space between the tenth and eleventh maxillary teeth; this is not due to an inequality of the fenestræ, but to an unsymmetrical arrangement of the teeth on opposite sides of the palatal borders.

INTERNAL NARIAL APERTURE.—The internal narial aperture is situated antero-posteriorly. It faces both downward and backward.

FORAMEN MAGNUM.—This foramen is large; it extends about half the distance from the superior border of the occipital condyle to the posterior border of the cranial table, and its breadth is somewhat greater than its height. Its large size is evidently correlated with the young stage of the specimen.



Amer. Mus. No. 8790

Fig. 5. Skull and jaws of *Crocodilus intermedius* Graves. Amer. Mus. No. 8790, two-thirds natural size. *A*, superior view of skull; *B*, lateral view of skull, left side; *C*, lateral view of mandible, left side; *D*, anterior view of mandible; *E*, inferior view of skull.

The Bones of the Skull

PREMAXILLARIES.—The anterior borders of the premaxillaries are incomplete; the bones are expanded laterally opposite the centers of the lateral borders of the external narial aperture. The two premaxillaries meet posterior to the aperture, completely excluding the nasals from the latter. The median suture of the two bones with each other, posterior to the aperture approximately equals the length of the aperture plus the length of the prenasal portions of the bones; the posterior processes, which wedge between the nasals and maxillaries, are broad and relatively short, extending only slightly further back than the level of the second maxillary teeth.

On the palate the premaxillaries are short. The premaxillo-maxillary suture extends on each side, directly inward from the "canine" notch, for a distance about one-fourth of the total distance across the palate at that level, then backward and slightly inward as far back as the space between the first and second maxillary teeth, then in an irregular transverse direction to the median line, and in a reverse direction to the opposite side.

Only three teeth are in each premaxillary in the specimen. Evidently there were four in the complete skull, as the nearly median first pair has obviously been lost during preparation. (Four are present in another specimen with the skin Amer. Mus. No. 10083). The dental borders of the premaxillaries are present anterior to the first teeth which are present, making it very unlikely that a tooth intervened in position on each side between this first tooth and the true first tooth of the jaw. The first tooth of the specimen, on each side, is therefore interpreted as being the second premaxillary tooth of the complete skull, homologous with the third premaxillary tooth of the crocodiles with five premaxillary teeth. The teeth are all spaced moderately far apart.

MAXILLARIES.—The maxillaries are long and slender. Their sutures with the nasals are nearly straight. Those with the lacrymals are irregular, being indented near their juncture with the nasals. The sutures with the jugals extend nearly directly forward throughout most of their length, then turn rather sharply inward. The combined maxillo-lacrymal and maxillo-jugal suture is very irregular in outline. Near their posterior ends the external surfaces of the maxillaries become vertical in position, in fact at their posterior ends they become reversed in position, — so that the external surfaces are partially visible from below.

On their palatal surfaces the maxillaries are characteristic in form — Each maxillary possesses an antero-posterior ridge extending midway between the median line and the dental border. The dental border is the

is slightly elevated, consequently the palatal profile across both maxillaries consists of four elevations, with three intervening depressions. The dental surfaces of the maxillaries face outward as well as downward, consequently the teeth also face partly outward.

The right maxillary contains thirteen teeth; the left contains only twelve. The first tooth on the left side and the second and third on the right side in the specimen are pressed downward against the bones; this may have been caused during preparation. All of the maxillary teeth except the last two, which are close together, are evenly spaced. The space between the first and second on the left side is greater than the rest, but this is clearly an abnormality correlated with the loss, or failure to develop, of the left second maxillary tooth; the space is actually that between the first and third maxillary teeth. The teeth increase regularly in size from the first to the fifth. The latter is only slightly greater than the others on the left side; on the right it is smaller than the fourth, but this is evidently due to the recent shedding of the fifth, and only incomplete replacement at the time of the animal's death; the alveolus is much greater than that of the fourth. Posterior to the fifth the maxillary teeth decrease irregularly in size. The last three or four of these teeth have relatively short crowns, but none of them are blunt. The anterior teeth are all very slender and most of them are slightly curved. Pits for reception of mandibular teeth are situated between the maxillary teeth from the first to the ninth; these pits are directly in line with the teeth themselves.

The maxillaries form small portions of the external walls of the palatine fenestræ, but no parts of the internal walls. The maxillo-palatine suture, on each side, extends inward and forward from the anterior end of the foramen in an irregular concave curve, then very near the median line turns in sharply in a slight convexity, then obliquely inward and forward in a straight line to the median line. The concave portion of the suture occupies about nine-tenths of its total length. The opposite sutures meet at the median line at the level of the anterior borders of the ninth maxillary teeth. The sutures with the ectopterygoids extend forward past two maxillary teeth. The maxillaries extend backward considerable distances posterior to the last maxillary teeth.

NASALS.—The nasal bones are relatively short for such a slender skull. Their anterior processes end opposite the first maxillary teeth; they are entirely excluded from the narial aperture by the premaxillaries. They broaden from the anterior to the posterior portions, as far back as their contacts with the maxillo-lacrymal sutures, or at the level of the

ninth maxillary teeth. Posterior to this they narrow rapidly; at their posterior ends they are wedged far apart by the anterior process of the frontal.

LACRYMALS.—The lacrymals are relatively large; they extend, in antero-posterior direction, from the ninth to the twelfth maxillary teeth and they occupy about twice as much area as the prefrontals. Their lateral borders are nearly parallel, and they converge in the anterior direction. Their anterior borders are irregular; they have been described above in discussing the maxillo-lacrymal sutures. The naso-lacrymal sutures are only slightly shorter than the naso-prefrontal sutures.

PREFRONTALS.—These bones are somewhat irregular in shape. Their internal borders, or sutures with the frontal and nasals, are slightly concave outward, and their external borders, or lacrymo-prefrontal sutures, extend forward and inward, the external and internal borders meeting anteriorly, opposite the space between the ninth and tenth maxillary teeth, in an acute angle. Their orbital borders are largely occupied by the supraorbital bones, or bony eyelids.

FRONTAL.—The frontal is long. Its anterior process, between the posterior ends of the nasals, is short and broad; posterior to the nasals and anterior to the frontal borders of the orbits the frontal is long and slender; the interorbital plate is narrow and flat. The posterior portion of the frontal, which comprises part of the cranial table, broadens rapidly from the narrow interorbital plate.

POSTORBITALS.—The postorbital bones are small, each of them occupying about one-fourth of the area occupied by the corresponding squamosal. The orbital border of each is somewhat greater than its portion of the external border of the cranial table. The postorbital portion of the latter is about one-fourth of its entire length.

SQUAMOSALS.—The squamosal bones occupy at least three-fourths of the lateral borders of the cranial table, and two-thirds of the posterior border. Their portions of the borders of the supratemporal fenestrae are much greater than those of the postorbitals, and slightly greater than those of the parietal. Their postero-external processes do not extend far out over the quadrates.

PARIETAL.—The parietal is relatively large. It occupies considerably more area than the frontal, and also more than the two squamosals together. Its greatest breadth is at its anterior end. Along the posterior border of the cranial table the space between the two squamosals, or about one-third of the border, is occupied by the parietal and supraoccipital together. Of this portion the supraoccipital occupies the

median half (one-sixth of the total border) and the parietal the small spaces between the supraoccipital and the squamosals. The breadth of the parietal between the supratemporal fenestræ is very great. The relatively large size of the bone, and especially its large interfenestral portion, is largely due to the immature condition of the specimen.

SUPRAOCCIPITAL.—The supraoccipital extends forward for a short distance on the cranial table; as noted above, this bone occupies about one-sixth of the posterior border of the table; its antero-posterior diameter, on the cranial table, is less than its transverse.

On the posterior surface of the skull the supraoccipital, at its broadest point, occupies about one-third of the total breadth of the cranium. Inferiorly it extends downward about five-sixths of the distance from the superior border to the foramen magnum.

BASIOCCIPITAL.—The occipital condyle of the basioccipital bends sharply downward, and the bone occupies a considerable space posterior to it on the inferior surface of the skull. This is evidently a youthful character.

BASISPHENOID.—This bone is not especially characteristic, except that the Eustachian foramen, which it surrounds, is directed largely downward, rather than largely backward. This also is an age character.

EXOCCIPITALS.—The exoccipitals are not characteristic, except for the youthful character of their extending somewhat farther forward on the inferior surface of the skull than they do typically.

QUADRATES.—These are not characteristic.

QUADRATO-JUGALS.—In these bones the free borders, which form the postero-superior borders of the infratemporal fenestræ, make considerable angles with the quadrato-jugal-jugal sutures, instead of continuing forward in the same direction as the latter. The sharp processes which extend into the fenestræ appear more as separate elements, and less as integral parts of the bones themselves.

JUGALS.—These bones are relatively long and slender. They extend forward to points slightly anterior to the level of the tenth maxillary teeth.

PALATINES.—The palatine bones are characteristic in form. The peculiar form of the maxillo-palatine suture has been described above. The broadest portions of the palatines is at the anterior ends of the palatine fenestræ. They compose all of the internal borders of the fenestræ except very small portions near the posterior ends. Their sutures with the pterygoids are anterior to the posterior ends of the fenestræ; each of them extends inward and backward for an exceedingly short

distance, then turns forward and inward at an angle of about 45° with the longitudinal axis of the skull to a point very near the median line; then it turns inward and backward for a distance of about one half millimeter, and meets its opposite at the median line. In general outline the palato-pterygoid suture parallels the maxillo-palatine suture in direction.

PTERYGOIDS.—The pterygoids are broad in proportion to their length. Each pterygoid occupies a considerable portion of the posterior border of the palatine fenestra. Posterior to the internal narial aperture the pterygoids send back a pair of short acuminate processes. Owing to the youthful stage of the specimen the pterygoids are situated rather forward on the palate, the narial aperture being under the center of the cranial table.

ECTOPTERYGOIDS.—These bones are somewhat irregular in form. Their anterior processes are slender, and are not very long; they do not extend as far forward as the level of the eleventh maxillary teeth. The inferior processes are directed in a more posterior direction than usual; they are rather stout, but taper to subacuminate terminations. The superior processes are slender.

SUPRAORBITALS.—The supraorbital bones, or bony eyelids, are very small. It is possible that their small size may be due to the immature stage of the specimen. Specimens of other crocodilians of similar size and of species which are somewhat larger than, or at least equally large as *C. intermedius* in the adult stages, have very large bony eyelids. Consequently the small size is probably a specific character.

The Mandible

The mandible is very long and slender. The symphysis is especially characteristic; it extends back to the level of the spaces between the seventh and eighth mandibular teeth. This is further back than in other species of *Crocodylus* except *C. cataphractus*. The splenials extend forward as far as the level of the eighth mandibular teeth, not quite reaching the symphysis.

The usual fifteen mandibular teeth of *Crocodylus* are present. They are all evenly spaced, and are slender and sharp, especially those in the anterior portion of the jaw. Many of the anterior teeth point outward to a certain extent, as well as upward. The fourth is the largest of the mandibular teeth, but the specimen studied is somewhat distorted in outline, and the fourth tooth on the right side is curved inward, somewhat obscuring its true characters.

The amount of festooning of the jaw, and of pits between the teeth for lodgment of maxillary teeth, is almost negligible; the lateral borders of the jaw converge in the anterior direction, however, as far forward as the fifth mandibular teeth, anterior to which they are approximately parallel. The greatest vertical height of each jaw is at the posterior end of the external mandibular foramen. On the supero-internal border of each articular bone is a small, but conspicuous foramen.

The specimen studied is considerably distorted, as mentioned above. This distortion is so great in the anterior region that the symphysis appears to be oblique in position, and the right first mandibular tooth is median in position.

Measurements Amer. Mus. No. 8790

Length of Skull, Tip of Snout to Supraoccipital	.123M.
Length of Skull, Tip of Snout to Condyle	.126
Length of Skull, Tip of Snout to Posterior Ends of Quadrates	.1285
Breadth Across Quadrato-jugals	.050
Breadth Across Cranial Table	.032
Breadth of Snout at Base	.030
Length of Snout, Anterior End of Orbit to Tip	.078
Length of Mandible	.148
Length of Right Orbit	.0225
Length of Left Orbit	.0230

Crocodilus johnstoni Krefft

No material was available for a direct study of the skull of this species. The following brief description is quoted from Boulenger. "19 upper teeth on each side. Snout very slender, Gavial-like, about three times as long as broad at the base, without distinct ridges; mandibular symphysis long, extending to the sixth tooth; maxillaries forming a median suture above, behind the nasal opening." The last character mentioned, is evidently a mistake; no true crocodile has the *maxillaries* meeting at the median line as in the gavial; evidently *premaxillaries* were meant.

Crocodilus niloticus Laurenti

The present description of the skull of this species is based upon a medium-sized, somewhat over half-grown specimen in the American Museum Collections (Amer. Mus. No. 10081).

General Form

The snout is moderately long, being slightly over one and two-thirds times as long as broad at the base. It is moderately broad at its anterior end, and is considerably constricted at the "canine" notches; it is greatly expanded at the level of the fifth maxillary teeth, and again constricted at the level of the space between the seventh and eighth maxillary teeth. It has a pair of prominent elevations above, internal to, and posterior to the fifth maxillary teeth; these elevations correspond with the very deep alveolar openings which lodge these fifth maxillary teeth. The snout is roughly pitted, but has no median elevation such as that of *C. americanus*; on the whole it is relatively low. Anterior to each orbit, and in line with the inferior border of the orbit, a very shallow groove extends forward and inward; this groove consists largely of an interruption of the pitting.

The cranial table is small, especially in the lateral direction; it is distinctly concave, differing in this respect from *C. americanus*. It is very rugose, and its lateral borders converge slightly; its posterior border is gently concave, with a prominent median process. The amount of vertical festooning, in both upper and lower jaws, is considerable. In general, the form of the skull resembles that of some of the stouter specimens of *C. americanus*, but is somewhat more robust than any of these.

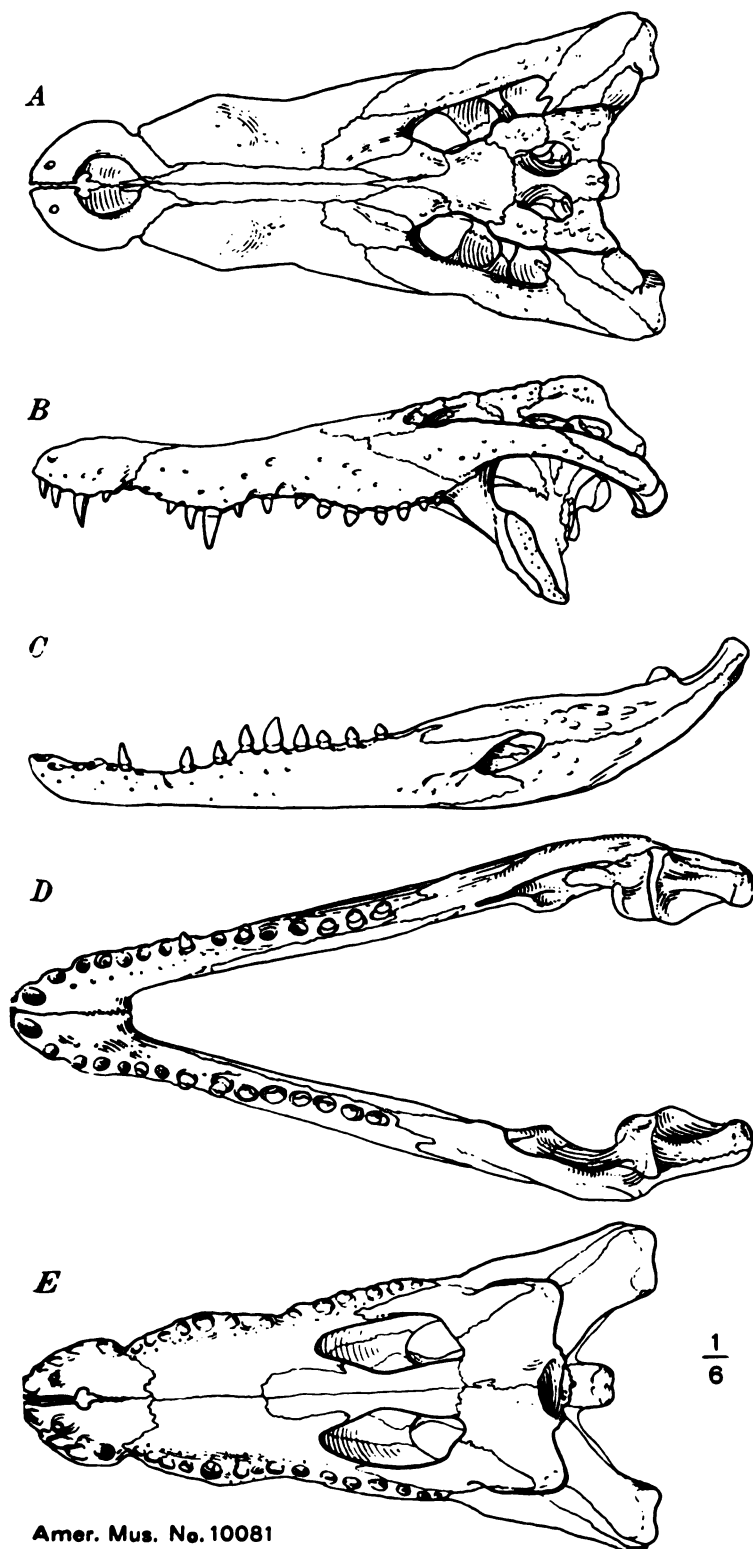
The Cavities of the Skull

SUPRATEMPORAL FENESTRÆ.—These cavities are small, and are very close together. They are irregular in outline, and their longitudinal diameters are greater than their transverse. They extend directly fore and aft and not oblique. The size of the two fenestræ together is somewhat smaller than that of the external narial aperture.

INFRATEMPORAL FENESTRÆ.—These cavities are of moderate size, and are more nearly quadrangular than triangular in outline. The posterior processes of the quadrato-jugals which enter them are relatively small.

ORBITS.—The orbits are rather large, and their longitudinal dimensions are considerably greater than their transverse. Their longitudinal axes are nearly parallel. They are far apart, and their superior margins are slightly uprolled throughout, and considerably so at their anterior and posterior ends.

EXTERNAL NARIAL APERTURE.—This cavity is large; its lateral borders are concave, and it is slightly pointed at its anterior and posterior ends. It is entered posteriorly by the anterior processes of the



Amer. Mus. No. 10081

6. Skull and jaws of *Crocodilus niloticus* Laurenti. Amer. Mus. No. 10081, one-sixth natural size. *A*, superior view of skull; *B*, lateral view of skull, left side; *C*, lateral view of mandible, left side; *D*, anterior view of mandible; *E*, inferior view of skull.

nasal bones. It is only slightly smaller than either of the orbits. In position it is situated far back on the snout; its anterior end is slightly posterior to the level of the third premaxillary teeth, and its posterior end is posterior to the level of the "canine" notches, and is opposite the level of the first maxillary teeth.

PREMAXILLARY FORAMEN.—The premaxillary foramen is small. It is heart-shaped in outline, and its length and breadth are about equal.

PALATINE FENESTRÆ.—The fenestræ are very large. They extend forward to the level of the space between the eighth and ninth maxillary teeth. Each of them is slightly pointed at its posterior end, and broadly rounded at its anterior end; its internal border is double in character, the anterior half extending forward, and its posterior half extending backward and outward; its external and postero-external borders are not sharply distinguished from each other.

INTERNAL NARIAL APERTURE.—The internal narial aperture is undivided by a median septum. It is large, especially in the lateral direction; it faces downward and backward, but not backward to the extent of *C. americanus*, *C. cataphractus*, or *C. intermedius*.

The Bones of the Skull

PREMAXILLARIES.—The premaxillary bones are distinctive in form. Their anterior portions, anterior to the nasal orifice, are relatively long, and are pierced by the inferior cavities which lodge the first mandibular teeth. The posterior portions, both of the broad area behind the aperture and the narrow posterior processes, are short. The bones are slightly elevated around the margins of the aperture. The posterior processes extend back very short distances, but reach the level of the space between the third and fourth maxillary teeth, in consequence of the backward position of the whole postnarial region of the bones; these short processes extend slightly outward as well as backward.

On the palate the premaxillaries are slightly broader than they are long. The suture with the maxillaries extends backward and inward, on each side, to a point opposite the center of the second maxillary tooth, then irregularly across the palate to the similar point on the opposite side, then forward and outward again. At the posterior extremity of each premaxillary, about midway between the dental border and the median line, is a sharp, low, irregular, backward pointing process; on one side there is a corresponding elevation of the maxillary. The fourth teeth are the largest in the premaxillaries; the third are somewhat smaller in size; the first and fifth are not preserved in the skull, but from

are altogether different from them in outline. Their sutures with the frontal curve gradually from the internal borders to the orbits, with no sharp angles at the postero-internal portions of the bones.

FRONTAL.—The anterior process of the frontal is very narrow; it sends forward a short projection between the posterior ends of the nasals. Its interorbital plate is relatively broad, and is concave in lateral profile. The bone does not extend back for any considerable distance behind the posterior ends of the orbits.

POSTORBITALS.—The postorbitals are small, especially in the lateral direction. They comprise about two-fifths of the lateral borders of the cranial table, and only very small portions of the borders of the orbits. The cranial and orbital borders are not sharply separated from each other. Their edges are somewhat elevated.

SQUAMOSALS.—The squamosals are considerably elevated along their lateral borders, and are very rough in these regions. Together they occupy about three-fourths of the posterior border of the cranial table.

PARIETAL.—This bone appears to be long; this is correlated with the very narrow interfenestral space. Its anterior border almost reaches the level of the posterior ends of the orbits. It occupies about one-fourth of the posterior border of the cranial table, and is extended backward for a short distance as a short process along the median line. The surface of the bone, posterior to the level of the posterior ends of the supra-temporal fenestræ, is rather deeply excavated.

SUPRAOCCIPITAL.—This bone has no part in the composition of the surface of the cranial table, but occupies a very small area of the surface of its posterior median projection, between the lateral portions of the posterior projection of the parietal mentioned above, and at a slightly lower level than the surface of the cranial table. On the posterior surface of the skull the supraoccipital extends downward about two-thirds of the distance from the superior border to the foramen magnum. It is very narrow, laterally, on this surface, and occupies scarcely one-fourth of the transverse dimension of the cranial table.

BASIOCCIPITAL, EXOCCIPITALS, BASISPHENOID, AND QUADRATES.—These bones are not characteristic of the species in their outlines or proportions.

QUADRATO-JUGALS.—The quadrato-jugal bones are short and stout. The anterior projection of the left one is broken off in the specimen, but the right one is preserved; it is rather short and broad. The antero-superior processes of the quadrato-jugals, along the contacts with the

come progressively shorter. The "canine" notches are short antero-posteriorly. The first and second, and second and third maxillary teeth, are close together; the third and fourth are slightly farther apart, and the fourth and fifth still farther apart. The fifth and sixth, the sixth and seventh, the seventh and eighth, and the eighth and ninth maxillary teeth are all rather widely spaced from each other. Posterior to the ninth the maxillary teeth are spaced progressively closer and closer together. Between all of the maxillary teeth anterior to the ninth are pits which receive mandibular teeth; between the sixth and seventh, and the seventh and eighth these pits are very deep. From the ninth maxillary teeth back to the end of the dental series the upper and lower teeth evidently bit against each other and not against the jaws themselves. The maxillary teeth might well be divided into two distinct groups; the anterior sharp teeth evidently acted more or less as a unit, while the posterior blunt teeth did the same. The external edges of the maxillaries are deflected downward on a rather large scale, so the bases of the teeth, in the anterior maxillary region, stand above the level of the palatal plate.

NASALS.—The anterior processes of the nasals, which are situated between the premaxillaries, broaden very rapidly, and the broadest region of the nasals is at the junction of the premaxillaries, maxillaries, and nasals with each other. From this point, which is slightly anterior to the level of the fourth maxillary teeth, the nasals narrow gradually to their minimum breadth, which is slightly anterior to the anterior ends of the naso-lacrymal sutures. From this point back they expand very slightly, and then converge rapidly in the posterior direction, ending, in this specimen, at the level of the eleventh maxillary teeth. The sutures of the nasals with the lacrymals are slightly shorter than their sutures with the prefrontals. The two nasals are very slightly wedged apart at their posterior ends by a very small anterior projection of the anterior process of the frontal.

LACRYMALS.—The lacrymals are large, occupying about twice as much area as the prefrontals. Their anterior extremities lie over the spaces between the eighth and ninth maxillary teeth; their sutures with the maxillaries are very irregular in outline. In shape they are relatively long and narrow, and they converge anteriorly only to a slight degree. Their sutures with the prefrontals are about two and one-half times as long as their sutures with the nasals.

PREFRONTALS.—These bones are long and narrow, and their greatest diameters converge very little, if at all, in the anterior direction. Their orbital borders are considerably shorter than their lacrymal borders, and

the thirteenth and fourteenth, and the fourteenth and fifteenth are far apart; the eighth and ninth are very far apart. The first eleven teeth have long crowns, the twelfth has a moderately short crown, and the thirteenth, fourteenth, and fifteenth have short crowns. The first twelve teeth are stout, but sharp-pointed, while the last three are blunt.

Measurements Amer. Mus. No. 10081

Length of Skull, Tip of Snout to Supraoccipital	.450M.
Length of Skull, Tip of Snout to Extremities of Quadrates	.503
Breadth of Skull Across Quadrato-jugals	.562
Breadth of Skull Across Anterior Ends of Orbits	.180
Breadth of Snout Across Fifth Maxillary Teeth	.146
Breadth of Snout Across "Canine" Notches	.086
Breadth of Snout Across Premaxillaries	.108
Breadth of Space Between Supratemporal Fenestræ	.010
Breadth of Space Between Orbits	.053
Length of Mandible, Total	.570
Length of Mandible, Left Ramus	.573
Breadth of Mandible	.310

Remarks

In many respects the skull of this species very closely resembles that of *Crocodylus americanus*. The proportions in the present species are about the same as those of a short-snouted individual of *C. americanus*. The elevation along the median line of the snout, which especially characterizes the latter species, is often lacking or feebly developed, so that the surface of the snout is often similar in the two species. Upon analyzing the detailed characters of the two species, however, a number of differences may be noted; the position of the external narial aperture in the two species is different; the shape and degree of separation of the supratemporal fenestræ are different; the relative breadth of the cranial table to the total breadth of the skull is different; the outlines of the borders of the cranial table and orbits are different; the shape of the anterior processes of the frontal in the two species is different; the shape of the quadrato-jugal is different; the shape of the premaxillary bones, both on the snout and on the palate, is different; the transverse profile of the cranial table is very different; the character of the interorbital plate is different; the forward extension of the palatine fenestræ is very different; the forward extension of the ectopterygoids is different; the shape and position of the internal narial aperture are different. These differences lead one to suspect that the similarities between the two species

quadrates, are very short; the right process does not extend farther forward than the process which enters the infratemporal fenestra.

JUGALS.—The jugals are stout; they extend forward to the level of the tenth maxillary teeth. Their anterior portions are somewhat expanded in the vertical direction.

PALATINES.—The suture of the palatines with the maxillaries has been described above. The suture with the pterygoids extends irregularly, but not far from transversely, across the interfenestral plate, slightly anterior to the posterior ends of the fenestræ. The palatines decrease in breadth a short distance posterior to the posterior ends of the maxillo-palatine sutures, the minimum diameter being opposite the eleventh maxillary teeth. From this point back they expand, until at their posterior ends they are broader than at their anterior ends.

PTERYGOIDS.—Each pterygoid occupies a very small portion of the posterior border of the corresponding palatine fenestra. The length of the two pterygoids along the median line is great, largely owing to the small antero-posterior diameter of the internal narial aperture.

ECTOPTYERYGOIDS.—These bones are relatively large. They extend as far forward as the level of the posterior ends of the alveoli of the tenth maxillary teeth. The anterior processes are only moderately broad; the postero-inferior and the superior processes are not especially stout.

The Mandible

The mandible of *C. niloticus* is very broad, and is composed of individually stout bones. The symphysis extends back as far as the posterior borders of the alveoli of the fifth mandibular teeth. The splenials extend forward as far as the seventh mandibular teeth. The external mandibular foramen is of moderate size in each ramus. The amount of vertical festooning of the jaws is very slight, and the degree of excavation of the sides of the two rami by the superior teeth is only noticeable at one point on each side, i.e., the space which receives the fourth maxillary tooth. The jaws each contain the usual fifteen teeth. There are not enough of these preserved in the specimen to enable one to determine their relative sizes accurately, but judging from their alveoli the first were the largest, the fourth second in size, and the eleventh next. The spacing of the teeth is very irregular. The third and fourth and the fifth and sixth teeth are very close together; the first and second, the fourth and fifth, the sixth and seventh, the ninth and tenth, the tenth and eleventh, and the eleventh and twelfth are moderately far apart; while the second and third, the seventh and eighth, the twelfth and thirteenth.

The Cavities of the Skull

SUPRATEMPORAL FENESTRÆ.—These cavities are relatively small; they are situated moderately close together. Their boundaries are somewhat upturned, especially near the median line. In outline each is sub-circular, the inner border being more rounded than the outer. The maximum length is nearly fore and aft in direction.

INFRATEMPORAL FENESTRÆ.—The infratemporal fenestræ are not sufficiently characteristic to warrant special description.

ORBITS.—The orbits are moderately large in size. In outline they are rounded.

EXTERNAL NARIAL APERTURE.—This cavity may be described as sharply oval in outline. It is somewhat rounded at its anterior end. Its length is about one and one-half times as great as its breadth. The nasal bones project, as a short process, into its otherwise pointed posterior end.

PREMAXILLARY FORAMEN.—This small cavity is broad in proportion to its length, compared with other species of *Crocodilus*. It is pear-shaped in outline, its anterior end being pointed, and its posterior end rounded; its lateral borders are simple curves.

PALATINE FENESTRÆ.—The palatine fenestræ are subquadrangular in outline. Their internal borders are nearly straight antero-posteriorly; their antero-internal borders are straight; the external borders are curved; the anterior ends are bluntly pointed; the postero-external borders are straight. The fenestræ extend forward to the level of the spaces between the eighth and ninth maxillary teeth.

INTERNAL NARIAL APERTURE.—This cavity is broad in proportion to its length.

The Bones of the Skull

PREMAXILLARIES.—On the superior surface of the snout the premaxillo-maxillary suture extends backward and inward on each side, at an angle of about 45° to the level of the second maxillary teeth, then extends almost directly backward to the level of the fourth maxillary teeth. From this point the premaxillo-nasal suture extends forward and inward to a point slightly posterior to the narial aperture, then directly forward to the aperture itself. On the opposite side the suture follows a reverse path.

On the palate the premaxillo-maxillary suture extends across the skull in an almost transverse direction. It swings slightly backward, however, reaching the level of the first maxillary teeth.

are not due to close relationship between them, but are more likely the result of parallel or convergent evolution, in adaptation to similar surroundings, similar habits, or similar food.

***Crocodylus palustris* Lesson**

The skull of this species is here described from one half-grown specimen in the Museum of Comparative Zoology and also from a disarticulated skull in the American Museum.

General Form

The skull is short and broad; the breadth across the quadratojugals, across the base of the snout, and across the premaxillary region is great in proportion to the total length of the skull. The premaxillary region is narrow in comparison with the snout and quadrato-jugal region. On each side is a slight but conspicuous notch at the premaxillo-maxillary suture which receives the fourth mandibular tooth; posterior to this the snout expands considerably to the level of the fifth maxillary teeth, then constricts again at the seventh, posterior to which it expands again. The length of the snout is about one and one-half times its breadth at the base. Its superior surface is flat in general, but it is crossed by three more or less concentric shallow grooves; these are U-shaped, with the concavities facing forward. The anterior one crosses the mid-line at the level of the fourth maxillary teeth, extending forward and outward, on each side, to the "canine" notch, immediately posterior to the premaxillo-maxillary suture. The second, whose lateral portions diverge more widely, crosses the mid-line between the levels of the fifth and sixth maxillary teeth. The third, which is larger than either the first or the second, crosses the mid-line at the level of the seventh maxillary teeth; the lateral arms of this groove are nearly parallel; they cross the lateral arms of the second groove. A fourth groove, which is small and irregular, crosses the mid-line at the level of the spaces between the eighth and ninth maxillary teeth. Above the spaces between the fifth and sixth maxillary teeth is a pair of rounded elevations; these evidently lodge the bases of the large fifth maxillary teeth.

The cranial table is flat. It is nearly rectangular in outline. The superior borders of the orbits are elevated into ridges; these continue in the anterior direction beyond the orbits, and turn inward immediately posterior to the maxillo-lacrymal sutures; they die out near the nasals. The external narial aperture is bounded by an elevation of the surface of the snout.

FRONTAL.—The anterior process of the frontal is very long and slender; it wedges apart the posterior ends of the nasal bones for a considerable distance. Its interorbital portion is somewhat concave.

SQUAMOSALS.—The squamosals are characterized by their flat postero-external corners.

PARIETAL.—The parietal bone has slightly elevated ridges surrounding the supratemporal fenestræ.

SUPRAOCCIPITAL.—This bone appears to occupy a small triangular area on the posterior edge of the cranial table. The sutures are not clear, however. On the posterior surface of the skull the supraoccipital occupies but little space. In the vertical direction it extends downward somewhat less than one-half the distance from the superior border to the foramen magnum. In the transverse direction also its extent is slight.

EXOCCIPITALS, BASIOCCIPITAL, BASISPHENOID, QUADRATES, AND POSTORBITALS.—These bones are not particularly characteristic.

QUADRATO-JUGALS.—The quadrato-jugals are relatively short and broad. Their anterior free processes are low in position, being nearer the quadrato-jugal-jugal sutures than the centers of the posterior borders.

JUGALS.—The jugals are not especially characteristic. They appear to be high vertically in proportion to their length.

PALATINES.—These bones extend forward in a sharp point at the median line. Their sutures with the maxillaries have been described above. They are relatively short; their anterior extremities extend as far forward as the level of the seventh maxillary teeth. The bones are broadest near the suture with the pterygoids. This suture is W-shaped, with the apex of the W directed forward.

PTERYGOIDS.—The pterygoids form only very small portions of the borders of the palatine fenestræ. Their posterior borders consist of two concave lines separated by the median notch.

ECTOPTERYGOIDS.—These bones are short and stout. Their anterior processes extend forward to the level of the eleventh maxillary teeth. Their vertical processes are nearly perpendicular to their anterior processes.

Mandible

The mandible is short and broad. The symphysis extends back to the level of the fourth mandibular teeth; the splenials do not extend forward close to the symphysis.

Each premaxillary contains five teeth. Of these the first is small, and is close to the median line. It is separated from the second by a considerable space, in the usual crocodilian manner. The pit which receives the first mandibular tooth lies partly between the first and second premaxillary teeth, and partly internal to them. The second tooth is small and is close to the third, which is approximately equal to the first in size. The third and fourth, and the fourth and fifth are spaced rather far apart, the spaces in the two cases being approximately equal. Pits are present in these spaces, and partly internal to them are the shallow depressions which receive the second and third mandibular teeth. The fourth tooth in each premaxillary is large, and the fifth is of medium size.

MAXILLARIES.—On the superior surface of the skull these bones are rather broad and short. The maxillo-nasal suture is practically forward in direction; the maxillo-lacrymal suture is transverse on each side.

The maxillo-palatine suture on the palatal surface of the skull tends, on each side, a considerable distance backward and inward from the anterior end of the palatine fenestra, then turns directly forward and at the level of the eighth maxillary teeth turns inward toward the median line; it meets this at the level of the anterior ends of the seventh maxillary teeth, or very slightly farther forward. The two opposite sutures meet each other with an acute angle. The maxillo-ectopterygial suture extends, on each side, from the level of the eleventh maxillary teeth to a point only slightly posterior to the last maxillary tooth.

Each maxillary contains fourteen teeth; the first six of these are short, but sharp, the last eight are short and blunt.

NASALS.—The nasal bones are long and slender. Their contacts with the premaxillaries have been noted above. They are broadest immediately anterior to their contacts with the lacrymals. The nasal lacrymal sutures are very short; the naso-prefrontal sutures are somewhat longer. Posteriorly the extremities of the nasals are separated by a long slender process of the frontal.

LACRYMALS.—These bones are of moderate size. They are approximately equal to the prefrontals in surface area, possibly being slightly smaller. In outline each lacrymal is crescentic, having a convex outer border for an anterior border, and a concave quarter circle for a posterior one. The orbital border of each lacrymal is slightly less than the orbital border of each prefrontal.

PREFRONTALS.—The prefrontal bones are large and conspicuous. They are irregularly hexagonal in outline.

pointed, except for the entrance of the nasal bones into the cavity with a short median process. The premaxillaries extend back from the anterior end as a very short median process.

PREMAXILLARY FORAMEN.—The inferior premaxillary foramen is very small, and is rounded triangular in outline.

PALATINE FENESTRÆ.—The palatine fenestræ are long and narrow in outline. Their external borders are nearly parallel straight lines, but have very gentle concave curvatures; anteriorly the fenestræ are rounded; near their posterior ends is a pair of oblique borders, which are equally external or posterior in direction; near the postero-internal ends of these borders the fenestræ terminate in sharp points; the internal borders are characteristic of the species; from the anterior ends of the fenestræ these borders extend backward and inward in the usual crocodilian manner, then extend outward again toward the posterior ends. This posterior expansion is very marked in the old individuals, and is correlated with the presence of a great expansion of the palatine bones, evidently surrounding an expansion of the nasal passage. The fenestræ extend as far forward as the ninth maxillary teeth.

INTERNAL NARIAL APERTURE.—This cavity is relatively very small, and is unusual in its position. It is situated at the posterior end of the palate, as in other crocodiles, but opens obliquely downward and backward, instead of downward in the usual manner.

The Bones of the Skull

PREMAXILLARIES.—The premaxillaries are comparatively broad in proportion to their length, especially in the older specimens. Their posterior processes extend back as far as the third maxillary teeth in some specimens, and not quite as far as the second in others. On the palate the premaxillo-maxillary suture extends backward as far as the second maxillary teeth; it is W-shaped, with the apex of the W directed forward; this apex does not extend farther forward, however, than the anterior borders of the first maxillary teeth.

There are five teeth in each premaxillary. The fourth is the largest, the third next in size, the first and fourth are about equal to each other and are smaller than the third, and the second is minute. In both young and old individuals the second is situated very close to the third, and in some cases the alveoli of the second and third are confluent. The pits which lodge the mandibular teeth are situated between the premaxillary teeth and not internal to them. The pits for the first mandibular teeth are very large, and in all the specimens studied open upon the superior

Measurements Specimen in Mus. Comp. Zool.

Length of Skull, Tip of Snout to Supraoccipital	.256M.
Length of Snout	.159
Breadth of Skull Across Quadrato-jugals	.147
Breadth of Cranial Table, Posterior End	.079
Breadth of Snout at Base	.112
Breadth of Snout Across Fifth Maxillary Teeth	.087
Length of Mandible	.308(est)

***Crocodylus porosus* Schneider**

The description is based upon a huge specimen in the Warren Collection in the American Museum (Amer. Mus. No. 15179) and two smaller specimens (Amer. Mus. Nos. 7131 and 7115). A number of characters have been verified on specimens in the Museum of Comparative Zoology.

General Form

The skull of *Crocodylus porosus* is characteristic in form. It is triangular in outline, and relatively short. The species is easily recognized by the very massive proportions of the skull bones, which are unusually thick, also by a pair of ridges which extend forward and very slightly inward from the anterior ends of the orbits. The snout is broad, but is not high; it is moderately sharp in young individuals and rounded in old ones. The lateral constrictions are deep and the vertical festooning pronounced, even in relatively young individuals, and in old ones the characters are developed to an excessive degree. The cranial table and interorbital spaces are more or less concave.

The Cavities of the Skull

SUPRATEMPORAL FENESTRÆ.—The supratemporal fenestræ are small and are subtriangular in outline. They are situated relatively close together.

INFRATEMPORAL FENESTRÆ.—The infratemporal fenestræ are usually small, especially in the older individuals.

ORBITS.—In the younger individuals the orbits are moderately large, each of them being larger than the narial aperture; in the old specimens the orbits are small, each being considerably smaller than the narial aperture. The orbits are round in outline, and are situated rather far apart.

EXTERNAL NARIAL APERTURE.—This cavity is of moderate size both in young and old individuals. It is rounded in outline, but broader in its anterior half than in its posterior. The posterior end

pointed, except for the entrance of the nasal bones into the cavity with a short median process. The premaxillaries extend back from the anterior end as a very short median process.

PREMAXILLARY FORAMEN.—The inferior premaxillary foramen is very small, and is rounded triangular in outline.

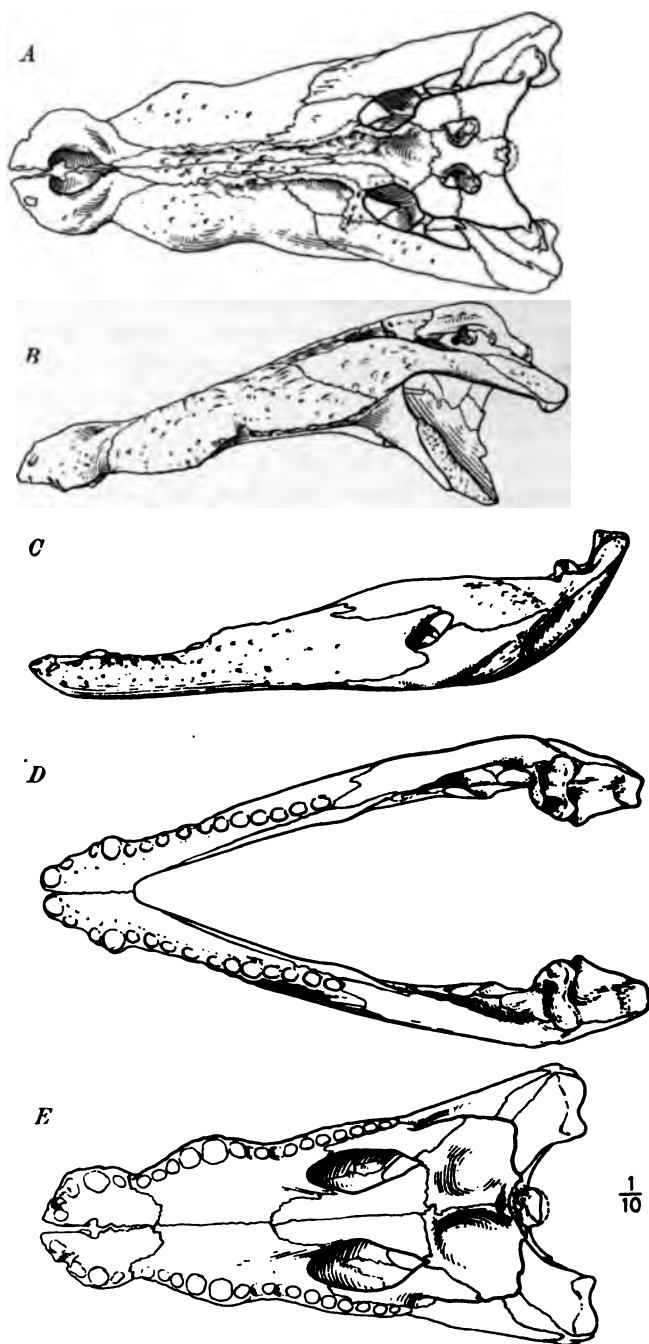
PALATINE FENESTRÆ.—The palatine fenestræ are long and narrow in outline. Their external borders are nearly parallel straight lines, but have very gentle concave curvatures; anteriorly the fenestræ are rounded; near their posterior ends is a pair of oblique borders, which are equally external or posterior in direction; near the postero-internal ends of these borders the fenestræ terminate in sharp points; the internal borders are characteristic of the species; from the anterior ends of the fenestræ these borders extend backward and inward in the usual crocodilian manner, then extend outward again toward the posterior ends. This posterior expansion is very marked in the old individuals, and is correlated with the presence of a great expansion of the palatine bones, evidently surrounding an expansion of the nasal passage. The fenestræ extend as far forward as the ninth maxillary teeth.

INTERNAL NARIAL APERTURE.—This cavity is relatively very small, and is unusual in its position. It is situated at the posterior end of the palate, as in other crocodiles, but opens obliquely downward and backward, instead of downward in the usual manner.

The Bones of the Skull

PREMAXILLARIES.—The premaxillaries are comparatively broad in proportion to their length, especially in the older specimens. Their posterior processes extend back as far as the third maxillary teeth in some specimens, and not quite as far as the second in others. On the palate the premaxillo-maxillary suture extends backward as far as the second maxillary teeth; it is W-shaped, with the apex of the W directed forward; this apex does not extend farther forward, however, than the anterior borders of the first maxillary teeth.

There are five teeth in each premaxillary. The fourth is the largest, the third next in size, the first and fourth are about equal to each other and are smaller than the third, and the second is minute. In both young and old individuals the second is situated very close to the third, and in some cases the alveoli of the second and third are confluent. The pits which lodge the mandibular teeth are situated between the premaxillary teeth and not internal to them. The pits for the first mandibular teeth are very large, and in all the specimens studied open upon the superior



Amer. Mus. No. 15179

Fig. 7. Skull and jaws of *Crocodilus porosus* Schneider. Amer. Mus. No. 15179, one-tenth natural size. A, superior view of skull; B, lateral view of skull, left side; C, lateral view of mandible, left side; D, superior view of mandible; E, inferior view of skull.

face of the skull as foramina. The pits for the second and third mandibular teeth are situated between the third and fourth, and fourth and fifth premaxillary teeth respectively; they are conspicuous in the young skulls, but are scarcely discernible in the great skull in the Warren Collection.

MAXILLARIES.—The maxillaries are relatively long. The maxillo-mandibular sutures extend along the preorbital ridges mentioned above. The sutures with the ectopterygoids extend as far forward as the tenth maxillary teeth. The maxillaries comprise practically no part of the external borders of the palatine fenestræ in the young specimens, in the older ones they occupy small places. The sutures with the palatines extend inward and backward short distances from the anterior ends of the fenestræ, then extend forward in irregular, but roughly parallel lines to a point opposite the seventh maxillary teeth, where they turn sharply inward and meet on the median line. The teeth increase regularly and steadily from the first to the fifth; posterior to the fifth they decrease in a more or less irregular manner. From the first to the sixth, the teeth of each maxillary are equally close together; the sixth and seventh, and seventh and eighth are separated by broad spaces which contain pits for reception of mandibular teeth; posterior to the eighth maxillary tooth the teeth are spaced somewhat closer together. In the two medium-sized skulls studied the right maxillaries contain thirteen teeth each and the left ones fourteen; in the large skull each maxillary contains fourteen teeth.

NASALS.—The nasals are very narrow; their posterior extension is somewhat variable, in some cases reaching nearly to the level of the orbits, in others being widely separated from the latter. At their anterior end they enter the narial aperture as a conspicuous process. The sutures with the lacrymals are very short; those with the prefrontals are considerably longer, and are variable in form. The two nasals are usually slightly wedged apart by a thin process of the frontal.

LACRYMALS.—The lacrymal bones are of medium size, and have nearly parallel internal and external borders; their sutures with the nasals are very short, but those with the prefrontals are long. They occupy the entire anterior ends of the orbits, and they carry the most prominent portions of the great preorbital ridges.

PREFRONTALS.—The prefrontals are long and slender. Their contacts with the nasals and with the frontal are about equal in length. They occupy about half of the superior, or internal, borders of the orbits.

FRONTAL.—The median frontal bone is very long in proportion to its breadth, especially in the younger individuals. The anterior process is narrow, and in Amer. Mus. No. 7131 it sends forward an exceedingly long and thin process between the nasals. The sutures with the two postorbital bones and the parietal together form a roughly semicircular figure; along the median line the suture with the parietal bends sharply backward on each side, the frontal sending back a small process into the parietal region.

POSTORBITALS.—The postorbital bones are small; at the surface they occupy scarcely one-half the space which is occupied by the squamosals; aside from this they are not characteristic.

SQUAMOSALS.—These bones are relatively large. As mentioned above, they are about twice the size of the postorbitals, and are relatively large in proportion to the other surrounding bones. Their postero-external processes are long and thick.

PARIETAL.—The parietal is of moderate size. Its shape at the surface follows very closely the outline of a cross-section of a T-rail. Its median portion, between the supratemporal fenestræ, is very small.

SUPRAOCCIPITAL.—The supraoccipital is relatively small. In the younger specimens it has no place in the cranial table, but in the huge skull in the Warren Collection it occupies a very small place at the posterior end of the table. On the posterior aspect of the skull the bone extends downward from one-half to three-fifths of the distance from the cranial table to the foramen magnum.

QUADRATES, EXOCCIPITALS, BASIOCCIPITAL, AND BASISPHENOID.—These bones are not especially characteristic, except for their thickness and massive construction.

QUADRATO-JUGALS.—The quadrato-jugals are broad at their postero-external ends, and they narrow considerably in the direction of their antero-internal ends. The characteristic *Crocodilus* process which extends into each infratemporal fenestra is very sharp.

JUGALS.—The jugals are characterized by their very great vertical height, which is unusually great in proportion to their length.

PALATINES.—The palatines are characteristic in form, especially in the older individuals. The suture with the maxillaries has been described above. That with the pterygoids is variable in outline; it may be directly transverse, irregularly curved, or a combination of a V and a W, with the long central apex directed forward. The palatines differ from those of other species in being greatly expanded posteriorly and superiorly to assist the pterygoids in enclosing a considerable enlargement of the nasal

passage. They extend forward to the level of the seventh maxillary teeth.

PTERYGOIDS.—The pterygoids are more or less characteristic in form. They occupy the posterior ends of the borders of the palatine fenestrae. The posterior portion of the palatine surface, which they occupy, is only slightly concave in the younger specimens, but is much more concave in the older ones. The anterior portions of the pterygoids join the palatines in enclosing the expansion of the nasal passage mentioned above.

ECTOPTYERYGOIDS.—These bones extend as far forward as the tenth maxillary teeth. Their inferior processes, which articulate with the pterygoids, are very stout; their superior and posterior processes, however, are relatively slender.

The Mandible

The mandible of *C. porosus* is characterized by a relatively great spread of the two rami in proportion to the length, and especially by the great vertical diameter and the great thickness and strength of the component bones. This is especially marked in the older individuals. The symphysis extends as far back as the fifth mandibular teeth.

The teeth are rather large in size, and are conspicuously striated. The usual crocodilian number of fifteen is present in each ramus, and the fourth is the largest and the eleventh next in size as is common in the genus *Crocodilus*. The first twelve teeth are subconical in form and are sharply pointed. The last three teeth are flat and blunt. The first and second, the seventh and eighth, the ninth and tenth, and the thirteenth and fourteenth teeth are moderately far apart, the second and third and the eighth and ninth are very far apart; the remainder of the teeth are close together. In the old Warren skull the jaw is distinctly festooned, to correspond with the outline of the maxillary border, but the amount of grooving for the reception of maxillary teeth is slight.

Measurements

	American Museum		
	No. 7115	No. 7131	No. 15179
Length of Skull, Tip of Snout to Supra-occipital	.305M.	.360M.	.642M.
Length of Skull, Tip of Snout to Ends of Quadrates	.335	.387	.721
Length of Snout	.205	.248	.464
Breadth of Skull, Across Quadrato-jugals	.160	.174	.369

Measurements (continued)

	American Museum		
	No. 7115	No. 7131	No. 15179
Breadth of Cranial Table, Posterior End	.090	.094	.177
Breadth of Snout at Base	.112	.121	.260
Breadth of Snout Across Fifth Maxillary Teeth	.087	.091	.220
Breadth of Snout Across "Canine" Notches	.048	.052	.131
Breadth of Snout Across Narial Aperture	.056	.065	.158(est.)
Length of Mandible	.370	....	.785
Breadth of Mandible	.147(est.)	.187	.390

Crocodylus rhombifer Cuvier

The material which forms the basis of the present description is one skull, 28.5 cm. long (Mus. Comp. Zool. No. 4042).

General Form

The shape of the skull in *Crocodylus rhombifer* is characteristic. The snout is short, being about one and one-half times as long as broad at the base. The snout differs from that of any other species of *Crocodylus* in being very high vertically in proportion to its breadth. In transverse profile the snout is triangular, the base of the triangle being the palatal surface, and the apex the median line of the snout. The name *rhombifer* refers to a rhombic plate, whose posterior borders are the internal borders of the orbits and whose anterior borders consist of a pair of oblique ridges converging in front of the orbits. This character is not well-marked in the specimen studied. The snout is broadly rounded anteriorly, and is considerably constricted at the "canine" notches; in spite of this constriction the portion of the snout between the two notches is broad. The constriction posterior to the sixth maxillary teeth is also conspicuous. The vertical festooning is very pronounced.

The cranial table is concave; and its postero-external angles project sharply outward and upward, much as in *C. robustus* Vaillant and Grandidier; these angles are exceedingly rugose, not with the normal crocodilian skull pitting, but with a much finer textured and irregular type of rugosity. The median posterior process of the cranial table is prominent. The lateral borders of the cranial table converge anteriorly to a marked degree, and the antero-external angles are not prominent. The pitting of the entire skull is somewhat finer textured than in most species of crocodiles.

The Cavities of the Skull

SUPRATEMPORAL FENESTRÆ.—These cavities are of moderate size, each being slightly smaller than the external narial aperture. They are subcircular in outline, and are close together.

INFRATEMPORAL FENESTRÆ.—These fenestræ are about equal in size to the supratemporal fenestræ; they are irregularly triangular in outline, and the quadrato-jugal processes on their postero-superior borders are small.

ORBITS.—The orbits are of moderate size, and are slightly longer than broad. They are rather widely separated. A small supraorbital bone, or bony eyelid, is present on the superior border of each orbit.

EXTERNAL NARIAL APERTURE.—This cavity is large, being intermediate in size between the orbits and the supratemporal fenestræ. It is subquadrangular in outline, and is somewhat longer than broad. The anterior processes of the nasals enter the orifice as a conspicuous prominence.

PREMAXILLARY FORAMEN.—The premaxillary foramen is small. It is heart-shaped, and is somewhat longer than broad.

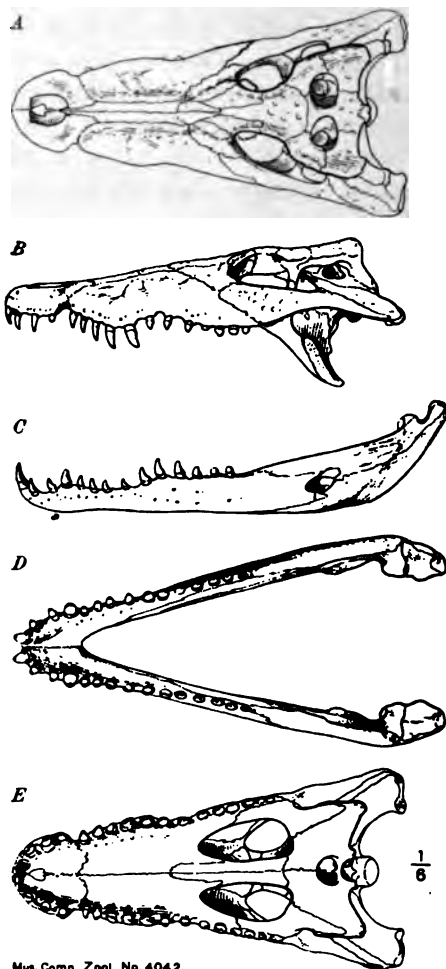
PALATINE FENESTRÆ.—The palatine fenestræ are large. They are separated from the teeth by broad plates of the maxillaries and ectopterygoids. They are somewhat irregular in shape; their anterior ends are sharply rounded and their posterior ends broadly rounded. Both the external and the internal borders of these fenestræ are concave. The cavities themselves are relatively broad in proportion to their length. They extend forward to the level of the eighth maxillary teeth.

INTERNAL NARIAL APERTURE.—This cavity is relatively large, and occupies a large portion of the pterygoids along their median line. It opens almost directly downward; it is divided by a median septum.

The Bones of the Skull

PREMAXILLARIES.—The premaxillaries are short and broad. Their posterior processes extend only slightly farther back than the level of the second maxillary teeth; these processes are broad. The premaxillaries narrow considerably at the "canine" notches, but in spite of this the snout is relatively broad at the notches. The anterior ends are broadly rounded.

On the palate the premaxillo-maxillary suture is very irregular in outline. It does not extend back of the level of the first maxillary teeth. It is situated nearer the first maxillary tooth on each side, than the last premaxillary tooth. The premaxillaries, therefore, occupy most of the



Mus. Comp. Zool. No. 4042

Fig. 8. Skull and jaws of *Crocodilus rhombifer* Cuvier. Mus. Comp. Zool. No. 4042, one-sixth natural size. A, superior view of skull; B, lateral view of skull, left side; C, lateral view of mandible, left side; D, superior view of mandible; E, inferior view of skull.

surfaces of the "canine" notches. Extending inward from the notch is a pair of shallow grooves, evidently used in lodging the fourth mandibular teeth during lateral movement of the jaws. The breadth of the palatal surfaces of the premaxillaries is somewhat greater than the length.

There are five teeth in each premaxillary; the fourth tooth is the largest. The teeth are all considerably stouter than those in other crocodilian skulls of the same size. They are situated on pedicles, with

grooves between, but the pedicles are not readily seen in a lateral view, as a downward projecting flange of the rim of the premaxillary hides the intervening grooves. The first tooth of each premaxillary is separated from the second by a very deep pit, which lodged the first mandibular tooth; this pit has, in each premaxillary, been extended upward to open on the superior surface as a conspicuous foramen; it is partly in line with the teeth themselves, and partly internal to them. The small second tooth is situated very close to the third tooth, the alveoli of the two being almost confluent. The third tooth is separated from the fourth, and the fourth from the fifth, by rather broad spaces. Each space is excavated into a deep pit, which extends inward a slight distance from the line of the teeth themselves.

MAXILLARIES.—The maxillary bones are broad, and are especially high in the vertical direction. They expand rapidly posterior to the "canine" notch, as far as the fifth maxillary teeth, then contract as far as the spaces between the sixth and seventh maxillary teeth; posterior to this level they increase in breadth rapidly. The maxillo-nasal sutures are irregular, but are essentially parallel; the maxillo-lacrymal sutures join the nasals with sharp angles slightly posterior to the level of the seventh maxillary teeth; they extend outward, downward, and backward, and are replaced by the maxillo-jugal sutures at the level spaces between the ninth and tenth maxillary teeth. Both of these sutures are irregular on a small scale, and the maxillo-jugal sutures are sharply indented near their inferior extremities.

On their palatal surfaces the maxillaries are relatively short and broad. Their suture with the premaxillaries has been described above. The suture with the palatines is characteristic in outline. On the internal border of each palatine fenestra the suture itself forms the border of the fenestra, from a point about one tooth's diameter from the anterior end, back for about the same distance, then it turns backward and inward to a level slightly posterior to the ninth maxillary teeth, then turns forward and gradually curves inward, meeting its opposite at the level of the spaces between the sixth and seventh maxillary teeth. The opposite portions of the maxillo-palatine suture are nearly parallel and close together for most of their length. The maxillaries, at the level of the seventh maxillary teeth, compose five-sixths of the distance across the palate. The maxillaries form about one-seventh of the internal border of the palatine fenestra on each side, and with the maxillo-palatine suture another seventh. Each maxillary forms about one-third of the external border of the corresponding fenestra; opposite the tenth maxillary tooth

the maxillo-ectopterygoid suture extends sharply inward from the edge of the fenestra to a point near the tooth. The portion of the maxillary which forms the border of the fenestra anterior to this suture, is very broad, separating the teeth from the fenestra by a considerable space. The posterior portion of each maxillary, along the longitudinal portion of the maxillo-ectopterygoid suture, is very narrow, the ectopterygoid being separated from the alveoli of the last three teeth by a very thin layer of the bone only.

There are fifteen teeth in each maxillary. They increase in size rapidly from the first to the fifth; the sixth, seventh, and eighth are somewhat smaller; the ninth is much larger than the eighth, and from it back to end of the series there is a steady decrease in size. All of the teeth are unusually stout for a crocodile skull of the size of the one studied. The anterior six or seven teeth are situated on pedestals, with pits between them; as in the premaxillaries, the pits and pedestals of each maxillary are largely hidden in a lateral view of the skull by vertical a flange of the external edge of the maxillary. The vertical festooning of the skull is considerable, and the descent from the prominence on which the large fifth tooth is situated, to the depression in which the sixth tooth is lodged, is very marked; this is greatly emphasized by the difference in size between the two teeth. The first eight maxillary teeth are relatively long-crowned and sharp-pointed; the ninth to thirteenth, inclusive, are short-crowned, relatively blunt, and elongated in the antero-posterior direction. The first five teeth are moderately and equally far apart from each other; they are separated by short spaces which include deep pits, which, in turn, lodge the mandibular teeth; the fifth and sixth, the sixth and seventh, and the seventh and eighth maxillary teeth are far apart, and the intervening pits are deep; posterior to the eighth the maxillary teeth are about equally spaced at moderate distances, with no intervening pits. The first five maxillary teeth are arranged in a rather unusual manner. They are stout, and are slightly curved; their concave inner surfaces face, not directly inward, but inward and backward; similarly their convex outer surfaces face outward and forward; these teeth therefore, are placed oblique to the longitudinal axis of the skull. They are parallel with each other and appear to have functioned more or less as a unit. The small, but rather sharp, sixth, seventh, and eighth maxillary teeth evidently likewise functioned as a unit. In both of these groups the maxillary and mandibular teeth interlock very closely, the mandibular teeth extending up into the pits of the maxillaries. The same is true of the premaxillaries. The maxillary teeth from the ninth

to the thirteenth, inclusive, must also have acted as a unit; between them the mandibular teeth do not reach the maxillary bones when the jaws are closed, but the maxillary and mandibular teeth bite against each other. This grouping of the maxillary teeth into separate regions, or units, is not confined to this species, but appears to be sufficiently emphasized in it to warrant special emphasis in the description.

NASALS.—The nasal bones of this species are distinctive in form. From their prominent anterior processes, which enter the narial orifice, they broaden rapidly in the posterior direction, as far back as the level of the second maxillary teeth, or to the posterior extremities of the premaxillaries; from this point back their lateral borders, the maxillo-nasal sutures, are somewhat irregular in outline on a small scale, but are not far from straight, and are essentially parallel. In the vicinity of the level of the eighth maxillary tooth, their lateral borders, which at that point consist of the naso-lacrymal sutures, converge sharply backward, meeting in an irregular manner at the level of the ninth maxillary teeth. The left nasal, in the skull studied, extends considerably farther back than the right; the two nasals are only very slightly separated by the anterior process of the frontal. The posterior portions of the nasals carry the anterior end of the rhombic elevation which gives the species its name.

LACRYMALS.—The lacrymals are rather characteristic in form and position. They carry the antero-lateral borders of the "rhomb." Their sutures with the prefrontals are more oblique than in most crocodiles, possibly in connection with the great height of the snout. The sutures of the lacrymals with the nasals are greater in length than the naso-prefrontal sutures, reversing the usual crocodilian condition. The longest axes of the bones themselves converge sharply in the anterior direction, making angles of nearly 45° with the longitudinal axis of the skull.

PREFRONTALS.—The sutures of the prefrontals with the nasals are unusually short. Their axes of greatest length converge anteriorly, but not to the extent of the axes of the lacrymals.

FRONTAL.—The frontal bone has a broadly concave posterior border; its anterior process is only slightly longer than its posterior plate. Its sutures with the prefrontals extend directly inward for short distances, then turn forward with sharp angles, contrasting somewhat with the gently curved sutures of most crocodiles.

POSTORBITALS.—The postorbitals are of medium size. Each of them has a greater extent along the lateral border of the cranial table than along the posterior border of the orbit, and each occupies an unusually

large extent of the anterior border of the corresponding supratemporal fenestra.

SQUAMOSALS.—These bones are of moderate size, and are sharply upturned at their postero-external extremities; in fact these extremities extend upward and outward as distinct processes. The posterior borders of the squamosals are greater than their lateral borders.

PARIETAL.—The parietal bone is unusually irregular in outline. Along its posterior border it extends outward as the base of a median posterior process, of which the supraoccipital occupies the apex. The parietal occupies somewhat over two-thirds of the portion of the posterior border of the cranial table which is situated between the squamosals. Immediately anterior to the supraoccipital the parietal is elevated into a strong rounded ridge, whose convex border faces forward.

SUPRAOCCIPITAL.—The superior, or cranial table, portion of the supraoccipital is small; it is elevated somewhat above the general level of the cranial table, and is confluent with the ridge of the parietal mentioned above.

On the posterior surface of the skull the supraoccipital extends downward about three-fourths of the distance from the superior border to the foramen magnum. Laterally this portion of the bone is not very broad, occupying but two-sevenths of the lateral extent of this surface of the skull.

QUADRATES, EXOCCIPITALS, BASIOCCIPITAL, AND BASISPHENOID.—These bones are not especially characteristic of the species, except for the type of stoutness which is characteristic of the skull as a whole.

QUADRATO-JUGALS.—These bones narrow very rapidly from the posterior to the anterior end. Their free processes are sharp, but are not large.

JUGALS.—The jugals are very slender at their extreme posterior ends, but otherwise are very deep vertically. At the level of the thirteenth maxillary teeth these bones are especially high.

PALATINES.—These are long and slender. Their sutures with the maxillaries have been described above. The suture with the pterygoids is only partly preserved, but appears to extend inward and slightly backward from a point near the posterior end of the palatine fenestra, then forward and inward to the median line. The narrowest diameter of the two palatines together is at the level of the spaces between the eleventh and twelfth maxillary teeth. The posterior ends are slightly expanded around an enlargement of the narial passage.

PTERYGOIDS.—The pterygoids are broad in proportion to their length. Their anterior borders converge rather sharply forward; the median line is occupied very largely by the unusually large internal narial orifice. The pterygoids occupy considerable portions of the broadly rounded posterior borders of the palatine fenestræ.

ECTOPTYERYGOIDS.—The anterior processes of the ectopterygoids, which extend as far forward as the level of the tenth maxillary teeth, are broad laterally. Their postero-inferior processes are short and are relatively stout; their superior processes are rather long.

The Mandible

The mandible is broad and stout, and is composed of individually stout bones. The lateral borders are slightly festooned. The symphysis extends back to the level of the anterior ends of the fifth maxillary teeth; the splenials extend farther forward than the level of the sixth maxillary teeth.

The teeth are all relatively large and strong. The fourth, on each side, is the largest, with the first a close second in size, followed by the tenth. The number of teeth is fifteen as in other true crocodiles; in form they resemble those of the upper jaw. The spacing of the teeth is very irregular; the wider spaces correspond with large teeth in the upper jaw, and the smaller spaces with smaller teeth. The first ten, on each side, are moderately long and pointed; the eleventh and twelfth are shorter and less sharp; the thirteenth and fourteenth are very short and blunt; the fifteenth is absent on both sides of the jaw, but it undoubtedly resembled the fourteenth.

Measurements Mus. Comp. Zool. No. 4042

Length of Skull, Tip of Snout to Supraoccipital	.28M.
Length of Skull, Tip of Snout to Ends of Quadrates	.32
Length of Snout	.18
Breadth of Snout at Base	.112
Breadth of Snout at Notch	.054
Breadth of Skull Across Quadrato-jugals	.16
Breadth of Cranial Table, Posterior End	.102
Breadth of Cranial Table, Anterior End	.073

Remarks

This species bears no close resemblance to any other known living crocodile in the form of its skull. The combination of short snout, very high median portion of the snout, and elevated postero-external angles of the squamosals are not known in any other species. *C. americanus*

has the median portion of the snout somewhat elevated, but its entire snout is much lower than in *C. rhombifer*; also the former species has much longer snout, and has practically no elevation of the angles of the squamosals; no other species has a high snout. The shortness of the snout is approached or equalled by *C. palustris*, and possibly the latest Pleistocene *C. robustus*, but both of these have very low snouts. The last-mentioned species resembles *C. rhombifer* in the elevation of the postero-external angles of the squamosals, but differs in having a lower snout, broader premaxillaries, and a different type of festooning. The only known connecting forms between this species and other crocodiles are the American Museum crocodiles from the Pleistocene of Cuba, collected by Mr. Barnum Brown and Dr. de la Torre, which may be referred to *C. rhombifer*, but which exhibit some characters, evidently more primitive, which may assist in bridging the gap between the skull of the modern *C. rhombifer*, and other crocodiles. These Pleistocene specimens will be described later.

***Crocodylus siamensis* Schneider**

No specimen of the skull of this species was available for study. The following description is quoted from Boulenger. "18 upper and 1 lower teeth on each side. Snout once and three fourths as long as broad at the base, rough but without any distinct ridges; interorbital space broad, with a median longitudinal ridge (which, in the specimen figured by Cuvier, is developed into a strong crest followed by another on the occiput); mandibular symphysis extending to the fourth tooth; premaxillo-maxillary suture, on the palate, directed backwards; premaxillaries narrowly separated above by the nasals."

OSTEOBLEPHARON Schmidt

GENERIC CHARACTERS

In this genus the cranial table is very flat, and the supratemporal fenestræ are small and widely separated from each other. The nasal bones enter the external narial aperture but do not divide it as in *Osteolemus*. The quadrato-jugals have the anterior processes as in *Crocodylus*. There are four teeth in each premaxillary and thirteen in each maxillary; fifteen teeth are present in each ramus of the mandible. The fifth maxillary teeth are enlarged. The fourth mandibular tooth on each side is received into a notch in the upper jaw. The amount of festooning of the skull is considerable. The maxillo-palatine suture does not extend forward beyond the level of the anterior ends of the palatine fenestræ. The

fronto-parietal suture enters the supratemporal fenestræ at their anterior ends. The symphysis extends to the fourth mandibular teeth, and does not include the splenial bones.

This genus resembles *Osteolæmus* in some respects and *Crocodylus* in others; in general it is intermediate between the two. It is somewhat more primitive than *Osteolæmus tetraspis*, and in some respects resembles some of the Eocene crocodiles.

***Osteoblepharon osborni* Schmidt**

The description of this species is based upon the type specimen (Amer. Mus. No. 10082), a skull of a half-grown individual.

General Form

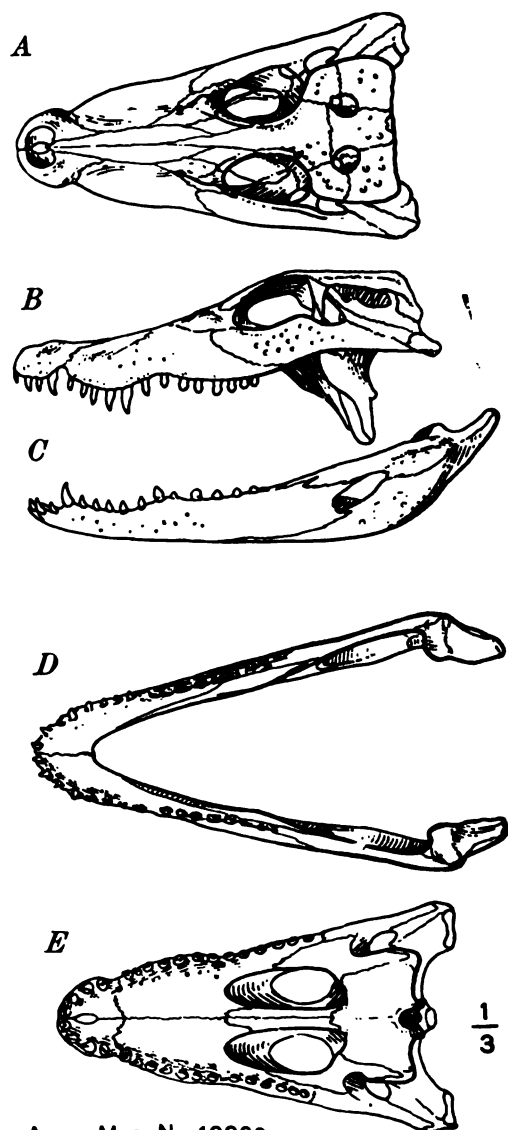
The skull of this species is moderately broad, and is rather high vertically, resembling somewhat in form the skull of *Osteolæmus tetraspis* Cope. A number of differences between the skulls of the two species may be noted, however.

The cranial table is broad and relatively short; its posterior border is a straight line; its external borders are symmetrically curved in slight convexities; the antero-external angles are gently rounded. The surface of the table is flat.

The snout is relatively short and broad, being only one and one-third times as long as broad at the base. The cross profile of the snout at the base consists of three more or less sharply differentiated planes, resembling somewhat those of *Caiman trigonatus*; these planes are not readily distinguishable in the anterior portion of the snout. There are faint suggestions of ridges on the snout, resembling those of some of the caimans, but they are not very prominent. The interorbital plate is rather broad, and is only very slightly rolled up at the edges. The tip of the snout is not turned up as in *Osteolæmus*.

One of the most characteristic features of the skull is a pair of bluntly pointed processes which extend outward from the flat superior surface of the snout immediately anterior to the orbits; they are situated entirely on the lacrymal bones.

The vertical festooning is very prominent, unusually so for so small a skull. The lateral constriction at the "canine" notch is very marked, but the one near the base of the snout is very faint.



Amer. Mus. No. 10082

Fig. 9. Skull and jaws of *Osteoblepharon osborni* Schmidt. Amer. Mus. No. 10082, type, third natural size. A, superior view of skull; B, lateral view of skull, left side; C, lateral view of mandible, left side; D, superior view of mandible; E, inferior view of skull.

The Cavities of the Skull

SUPRATEMPORAL FENESTRÆ.—These cavities are small; they are irregularly elongate oval in outline; their longitudinal axes diverge slightly in the anterior direction. They are separated rather widely from each other, and are nearly equidistant from the anterior, external, and posterior borders. The fronto-parietal suture enters the fenestræ at their anterior ends.

INFRATEMPORAL FENESTRÆ.—The infratemporal fenestræ are small. Each of them consists of an irregular acute triangle whose apex is superior in position. The anterior border is straight, the base is concave upward, and the posterior border is irregular.

ORBITS.—The orbits are large. They are very irregular in outline, the supero-internal borders being strongly concave and the infero-external borders very slightly concave. The anterior ends are bluntly pointed.

EXTERNAL NARIAL APERTURE.—This cavity is of moderate size, being much smaller than the orbits, and larger than the supratemporal fenestræ, and it is surrounded by a low, more or less indistinct ridge. It is subquadrangular in outline, and it is not divided by a median bony septum, though there is a prominent process, composed of the anterior tips of the nasal bones, which enters it at its posterior end.

PREMAXILLARY FORAMEN.—The premaxillary foramen on the palate is very small. It is irregularly lens-shaped, the anterior end being very sharply pointed, the posterior end more blunt.

PALATINE FENESTRÆ.—The palatine fenestræ are long and narrow, the length of each being about two and one-half times its breadth. In form these fenestræ are very irregular. The internal corner of each is a straight line throughout most of its length. The inner third of the posterior border is almost directly transverse in direction; the external two-thirds extends outward and forward obliquely; this latter portion belongs equally to the posterior and external borders. The external border is gently concave for most of its length. The anterior end is rather sharply rounded, the external and internal borders converging into a bluntly rounded point. The fenestræ extend as far forward as the level of the spaces between the seventh and eighth maxillary teeth.

INTERNAL NARIAL APERTURE.—This opening is small and is circular in outline. It is situated at the extreme posterior end of the palate, and faces downward and slightly backward. Its anterior border only is elevated; it is not divided by a median septum.

The Bones of the Skull

PREMAXILLARIES.—The premaxillary bones are relatively short and broad. They are separated posterior to the narial aperture by the relatively broad anterior processes of the nasals. They narrow considerably at the "canine" notch. The premaxillo-maxillary suture extends almost transversely inward for a short distance, and then turns almost directly backward. The posterior processes extend back beyond the level of the third maxillary teeth, but not as far back as the level of the fourth.

On the palate the premaxillaries are broader than long. The premaxillo-maxillary suture is irregularly transverse in direction. Its most posterior extension, at the median line, extends scarcely behind the level of the first maxillary teeth. A short distance in from the "canine" notch the suture is interrupted, on each side, by a conspicuous foramen.

There are four teeth in each premaxillary. The second premaxillary teeth of *Crocodylus* appear to have no homologues in *Osteoblepharon*. The first teeth are the smallest and the fourth are next in size. On the left side the third is the largest tooth, and on the right side the second is largest. The third tooth on the right side does not completely fill its alveolus, however, and is evidently very young. The third teeth, therefore, are the largest, and the second teeth next in size in the premaxillaries. The teeth are evenly spaced, and the pits which receive the mandibular teeth are between the teeth themselves, and not internal to them.

MAXILLARIES.—The maxillaries are relatively short and broad. The sutures with the nasals are especially short, being little longer than the sutures with the lacrymals and shorter than the sutures with the jugals.

On the palate the maxillaries form about two-fifths of the external borders of the palatine fenestræ, and about one-fifth of the internal borders. These internal borders are actually composed of two bones, the maxillaries forming the borders at the palatal surface, and the palatine at a deeper level; the suture between the maxillaries and the palatine extends horizontally along the borders themselves. The portion of each maxillo-palatine suture at the surface is characteristic in form. It extends inward from the palatine fenestra about opposite the ninth maxillary tooth in a transverse direction, then curves forward and inward to meet its opposite at the median line at the level of the spaces between the seventh and eighth maxillary teeth, only a slight distance anterior to the anterior ends of the palatine fenestræ. This condition contrasts strongly

with that of most crocodilians, in which the suture extends far in front of these fenestræ. It is approached more closely by some of the Eocene crocodiles than by the living ones.

There are fourteen maxillary teeth on each side; these increase regularly in size from the first to the fifth, as in *Crocodilus*. The sixth teeth and the teeth posterior to them are much smaller than the fifth. The anterior six or seven maxillary teeth are slender and sharp, resembling those of the premaxillaries; those farther back have short blunt crowns. The alveoli of the last two teeth are continuous with each other. The internal wall of the posterior half of the compound alveolus is composed of a portion of the ectopterygoid bone and not of the maxillary. The sixth and seventh, and seventh and eighth maxillary teeth are rather widely spaced from each other; all the other maxillary teeth are closely and evenly spaced. A pair of deep foramina is situated immediately internal to the sixth maxillary teeth. There is a very slight lateral constriction of the snout at the level of the seventh maxillary teeth. Vertically, the lateral, or external, border of each maxillary descends rapidly from the "canine" notch to the fourth and fifth maxillary teeth, then rises to the space between the seventh and eighth teeth, posterior to which it descends gradually. The only conspicuous pits for reception of mandibular teeth are between the sixth and seventh, and the seventh and eighth maxillary teeth; these pits are slightly internal to the line of the teeth.

NASALS.—The nasal bones are broad. Their external borders are characteristic, being simple, gently convex curves from end to end. The anterior portion, which wedges in between the premaxillaries, is broad, and forms a conspicuous projection into the nasal aperture. The sutures with the maxillaries are very short; these with the lacrymals are relatively long, while those with the prefrontals are very short. At their posterior ends the nasals are wedged apart by a long anterior process of the frontal, which separates them for a considerable distance.

LACRYMALS.—The lacrymals are very large compared with those of other crocodile skulls of similar size. Each of them forms a large part of the anterior border of the orbit, both above and below the anterior point of the latter. A conspicuous projection extends outward from each lacrymal.

PREFRONTALS.—The prefrontal bones are small and are very irregular in shape. They are much longer than they are broad; their sutures with the frontal and lacrymals are moderately long, but their sutures with the nasals and also their portions of the superior borders of the orbits are very short.

FRONTAL.—The frontal bone is very long in proportion to its breadth. Its broader posterior portion extends as far back as the level of the anterior ends of the supratemporal fenestræ; in fact the bone occupies a very small portion of the anterior wall of each of these fenestræ. The interorbital portion is comparatively broad. The long anterior portion is a simple V in outline, the prefronto-frontal and nasofrontal sutures forming straight lines continuous with each other. The anterior process extends as far forward as the level of the eighth maxillary teeth.

POSTORBITALS.—These bones are relatively small. They are subquadrangular in outline, and occupy only small portions of the posterior boundaries of the orbits, the external borders of the cranial table, and the external borders of the supratemporal fenestræ.

SQUAMOSALS.—The squamosal bones are large; they are subquadrangular in outline, and occupy about twice as much space on the surface of the cranial table as do the postorbitals.

PARIETAL.—The parietal is considerably longer than it is broad. It is slightly broader at the anterior end than at the posterior. It occupies about half of the space along the posterior border of the cranial table between the two squamosals, the supraoccipital occupying the other half.

SUPRAOCCIPITAL.—The supraoccipital occupies about half of the space between the squamosals on the posterior border of the cranial table, its antero-posterior diameter on the cranial table is less than one-half its lateral diameter. On the posterior surface of the skull it extends downward about three-fifths of the distance from the superior border to the foramen magnum.

QUADRATES, EXOCCIPITALS, BASIOCCIPITAL, AND BASISPHENOID.—These bones are not sufficiently characteristic to warrant description at the present time.

QUADRATO-JUGALS.—These bones are long and slender in two dimensions, and thick in the other at the posterior ends, where they cover the quadrates. They have processes extending into the infra-temporal fenestræ as in *Crocodylus* and *Tomistoma*, but the processes are not so sharply pointed as in the latter genera.

JUGALS.—The jugals are deep vertically in their anterior portions, and shallow near their posterior ends; each of them has a superior process at the posterior end of the orbit.

PALATINES.—The palatines are long and slender; their sutures with the maxillaries have been described above. They do not extend

as far in the posterior direction as the palatine fenestræ, the sutures with the pterygoids consequently extending only across the narrow bar separating the two fenestræ. This short suture is irregular in outline.

PTERYGIDS.—The pterygoids appear to have fused into a single bone. They occupy considerable portions of the borders of the palatine fenestræ; they are somewhat broader than long, and curve downward at their external borders, making the pterygoid surface of the palate concave. A faint ridge is situated anterior to the internal nasal aperture and partly surrounding it. Two small processes extend backward beyond the palate.

ECTOPTYRGIDS.—The ectopterygoids occupy portions of the posterior borders of the palatine fenestræ as well as the external borders, and they form the internal wall of the alveolus of each of the last maxillary teeth. They extend as far forward as the level of the spaces between the tenth and eleventh maxillary teeth.

The Mandible

In general form each ramus of the mandible is slender, though the two rami together make a rather broad jaw. The symphysis extends as far back as the level of the anterior ends of the fifth mandibular teeth. The external mandibular foramina are small, and are situated far back in the normal crocodilian position.

The dentaries are long and slender. Each contains fifteen teeth only, as in *Crocodilus*. The bones are peculiar in that they do not constitute the internal wall of the compound alveolus of the last three mandibular teeth. The first three teeth are of small or medium size, and are spaced regularly at moderate distances from each other. The fourth teeth are the largest in the jaw. Posterior to the fourth the teeth are small and are spaced close together as far back as the eighth; between the eighth and ninth teeth are considerable spaces; posterior to the eighth the teeth are all close together. The tenth and eleventh teeth are larger than those immediately anterior to them. The twelfth, thirteenth, fourteenth, and fifteenth teeth are small. As far back as the eleventh the teeth are slender and sharply pointed; posterior to the eleventh they are small and blunt. The superior borders of the mandible, as shown on the dentaries, are festooned in the reverse order from the maxillaries.

The splenials extend as far forward as the sixth mandibular teeth. They form the internal walls of the compound alveoli of the fourteenth and fifteenth mandibular teeth; in the region of these teeth each splenial sends a small shelf-like process inward toward the median line.

The angular, surangular, and coronoid bones are not sufficiently characteristic to warrant special description.

The articular surfaces of the articular bones are rather long antero-posteriorly. They are characterized especially by the oblique, inturned positions of the posterior processes.

Measurements Amer. Mus. No. 10082

Length of Skull, Tip of Snout to Supraoccipital	16.65cm.
Length of Skull, Tip of Snout to Ends of Quadrates	16.4
Length of Snout, Anterior End of Orbit to Tip	8.5
Breadth of Skull, Across Quadrato-jugals	9.25
Breadth of Cranial Table	5.9
Breadth of Snout at Base	6.4
Breadth of Snout Opposite Fifth Maxillary Teeth	5.2
Breadth of Snout at "Canine" Notch	3.2
Breadth of Snout Opposite External Narial Aperture	3.55

Remarks

In its general form, its large flat cranial table, and in some of the details of its bones the skull of this species resembles that of *Osteolæmus tetraspis* rather closely. In other characters it differs appreciably from the latter crocodile. In many characters *Osteoblepharon osborni* resembles *Crocodilus* as closely as it does *Osteolæmus*. In certain characters *Osteoblepharon* is more primitive than *Osteolæmus* or *Crocodilus*, and stands intermediate between the two genera. It appears to be only distantly related to *Tomistoma*, *Caiman*, and *Jacare*, and still more distantly to *Gavialis* and *Alligator*. The present interpretation is that *Osteoblepharon* has descended from some primitive species of *Crocodilus* or a form very closely related to that genus, and has retained a few primitive characters which the Recent species of *Crocodilus* have lost, and at the same time has developed some new characters which are not known in *Crocodilus*. *Osteolæmus* is evidently a more specialized form, and may perhaps be a derivative of *Osteoblepharon*.

OSTEOLÆMUS Cope

GENERIC CHARACTERS

This genus resembles *Osteoblepharon* in many of its characters. In it the cranial table is large and flat, and the supratemporal fenestræ are small, and are far apart; the fronto-parietal suture does not enter the fenestræ. The nasal bones extend forward into the external narial aperture, and divide it into two lateral portions as in *Alligator*. The snout

is short and is considerably indented. The tip of the snout is turned upward, giving the superior profile of the snout a concave curve. The upper eyelids are bony.

The premaxillaries contain four teeth each, and the maxillaries thirteen each typically; the mandible contains fourteen or fifteen teeth in each ramus. The fourth mandibular teeth bite into notches in the snout, as in *Crocodilus*. The symphysis extends to the fourth or fifth mandibular teeth, and does not contain the splenials, and the quadrato-jugals possess sharp anterior processes.

The fifth maxillary tooth on each side is somewhat enlarged. The maxillo-palatine suture does not extend forward beyond the anterior ends of the palatine fenestræ; these fenestræ are very irregular in outline.

This genus is evidently closely related to *Osteoblepharon*, and less closely to *Crocodilus*. It is more specialized in several respects than either of these genera.

Osteolæmus tetraspis Cope

This description of *Osteolæmus tetraspis* is based chiefly upon a small skull in the American Museum Collection (Amer. Mus. No. 7743), also upon published descriptions and figures. Judging from a number of characters, not including its small size, the skull is that of a young individual. Among these characters may be mentioned the large size of the orbits, the number of teeth (four or five) beneath the orbits, the small size of the interorbital plate, the amount of cranial overhang when the skull is viewed from below, the weakness of the various rugosities, and the incomplete appearance of the mandibular dental series. The size is small, but the maximum size listed by Boulenger for the species is not great; this skull evidently belonged to an individual much smaller than the maximum size.

General Form

The skull is short and broad, and moderately high. The snout is about one and one-fifth times as long as broad at the base; the length of the snout is approximately one-half of the total length of the skull from the tip of the snout to the ends of the quadrates. The superior longitudinal profile of the snout is decidedly concave, and the rim of the external narial aperture is elevated. In general the snout is smooth, but anterior to each orbit is a small prominence, and on each maxillary bone, near its anterior end, is a shallow depression. The lateral constrictions of the snout are deep, and the amount of vertical festooning is considerable.

The cranial table is moderately large, and is flat. It is approximately quadrangular in outline; its lateral borders are substantially parallel, and its posterior border is very gently concave. The antero-external angles of the table are neither rounded nor sharp. The interorbital plate is deeply concave.

The Cavities of the Skull

SUPRATEMPORAL FENESTRÆ.—The supratemporal fenestræ are very small; they are very irregular in outline, and are far apart from each other. Their axes of greatest length converge very sharply in the posterior direction.

INFRATEMPORAL FENESTRÆ.—These cavities are very much larger than the supratemporal fenestræ, and are irregularly subtriangular in outline. They differ from the corresponding fenestræ of most crocodilians in having their vertical diameters very much greater than their antero-posterior.

ORBITS.—The orbits are very large. They are subcircular in outline, but their superior, or internal, borders are more concave than their inferior, or external, borders; they consequently appear to be very slightly pointed at their anterior ends. Their superior borders are conspicuously rolled upward.

EXTERNAL NARIAL APERTURE.—The external narial aperture is very large. It is divided longitudinally, at the surface, by the anterior processes of the nasal bones, which extend forward and join shorter processes of the premaxillaries extending backward from the anterior margin of the aperture, similar to the condition in *Alligator*. The anterior end of the aperture is very near the anterior margin of the snout; the posterior margin is slightly posterior to the level of the last premaxillary teeth.

PREMAXILLARY FORAMEN.—The premaxillary foramen on the palate is very small. It is sharply pointed at its anterior and posterior ends, and its two lateral borders are simple concave curves.

PALATINE FENESTRÆ.—The palatine fenestræ are large and very irregular in outline. They extend forward to the level of the spaces between the seventh and eighth maxillary teeth. Between one-fourth and one-fifth of the internal border of each fenestra is composed of the maxillary bone, and this portion is not in direct line with the palatine portion immediately posterior to it. The maxillary portion is oblique, and the anterior part of the palatine portion is nearly antero-posterior. This palatine portion quickly turns inward, however, and sweeps around.

in a deep concavity, to an point near the posterior end of the fenestra. The posterior portion of the internal border, about one-tenth or one-twelfth, is composed of a portion of the pterygoid bone.

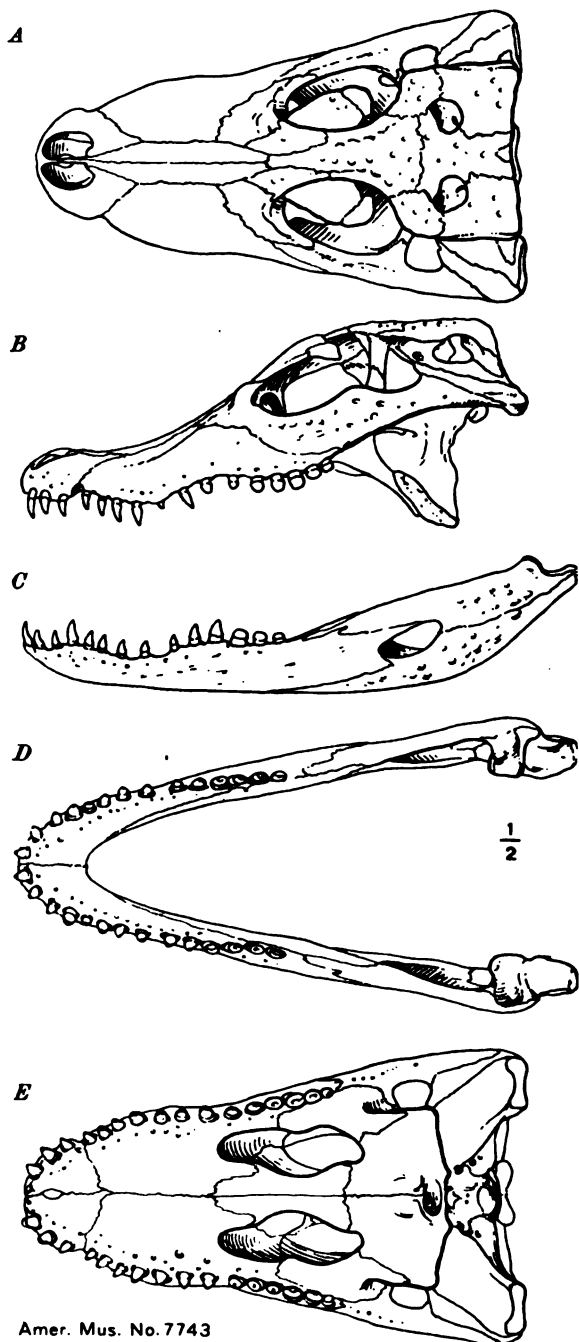
The external border, on each side, is likewise very irregular. The anterior two-fifths is composed of the maxillary bone; this portion is slightly concave; immediately posterior to it is the ectopterygoid portion, which extends abruptly into the fenestra, and then follows a very concave path of its own to a point very near the posterior end of the fenestra. A very small portion of the external border, perhaps one-fifteenth, is composed of the pterygoid. Both anterior and posterior ends of the fenestræ are rounded.

INTERNAL NARIAL APERTURE.—The internal narial aperture is rather small; its breadth is considerably greater than its length. It is not divided by a median septum, and it faces almost directly downward.

The Bones of the Skull

PREMAXILLARIES.—The premaxillary bones are very short and broad. The greatest constriction at the "canine" notches is on the premaxillaries, but between these notches they are much broader than they are long. Their posterior processes are very broad, and are not sharply separated from the posterior region of the bone in general; they extend as far back as the level of the third maxillary teeth. A slender process extends back from the anterior margin of the external narial aperture to join the anterior processes of the nasals.

On the palate the premaxillaries are very much broader than long. The premaxillo-maxillary suture extends inward and backward from each side and meets its opposite on the median line at the level of the second maxillary teeth. The two lateral components of the suture together form an irregular V. In the specimen studied only three teeth are present in each premaxillary; the anterior portions of the palatal surfaces of the premaxillaries are not complete, however, and there are indications of a pair of small alveoli. In the figure of the palate of *Osteolaemus* in Schmidt's article on the Congo Reptilia (after Gray), a pair of small alveoli are represented near the median line. The species therefore undoubtedly has four teeth in each premaxillary. There is no trace of the very small second tooth of the more primitive crocodilians. The teeth are about equally spaced apart, and are separated by deep pits which lodge mandibular teeth; these pits are slightly internal to the lines of the teeth themselves.



Amer. Mus. No. 7743

Fig. 10. Skull and jaws of *Osteolæmus tetraspis* Cope. Amer. Mus. No. 7743, two-thirds natural size. A, superior view of skull; B, lateral view of skull, left side; C, lateral view of mandible, left side; D, superior view of mandible; E, inferior view of skull.

MAXILLARIES.—The superior portions of the maxillaries are exceedingly short and the inferior portions are moderately so. The maxillo-nasal sutures are less than one-third as long as the total length of the maxillary bones. Their sutures with the lacrymals are very irregular; their sutures with the jugals are very short in the antero-posterior direction. As noted above, the maxillaries, in the antero-internal portions of their superior surfaces, lodge a pair of shallow depressions.

On their palatal surfaces the maxillaries are unusually short and broad. The length of the two maxillaries along the median line is very much less than their transverse diameter at any point. The maxillaries comprise portions of the internal borders of the palatine fenestræ, as noted above. From a point opposite the ninth maxillary tooth, each maxillo-palatine suture extends inward and backward a very slight distance, then turns forward, and extends in a direction only very slightly inward and almost antero-posterior, to a point opposite the seventh maxillary tooth, and then extends irregularly inward to meet its opposite at the median line. In its forward extent and its outline, the maxillo-palatine suture of this specimen differs slightly from the one figured by Gray and Schmidt.

The maxillary portions of the external borders of the palatine fenestræ are broad laterally, extending inward from the dental borders. From the anterior ends of the maxillo-ectopterygoid sutures (which extend forward to the level of the tenth maxillary teeth) backward, the borders of the maxillaries are very narrow; opposite the last and next to the last maxillary teeth the internal walls of the alveoli are at least very thin, and may possibly be absent altogether, so far as the maxillaries are concerned, the ectopterygoids taking their places. The maxillaries do not extend back for any considerable distances posterior to the dental series.

The right maxillary contains thirteen teeth and the left twelve. The specimen figured by Gray and Schmidt has twelve in each maxillary. There is a progressive increase in the size of the teeth from the first to the fifth (on the right side of the skull studied the fifth tooth is small, but its alveolus is large). The sixth, seventh, eighth, and ninth teeth are smaller; the tenth is slightly larger, the eleventh larger still, while the twelfth is small, and thirteenth is exceedingly small.

The first seven teeth in each maxillary are long-crowned, sharp-pointed, and blade-like in form, and their external surfaces are curved more than their internal surfaces; the eighth is short-crowned, but is sharp; posterior to the eighth the teeth are all very short-crowned and

are very blunt. The demarkation of the maxillary teeth into distinct tearing and chewing groups is very marked. The anterior seven teeth in each maxillary are all moderately far apart from each other; they are separated by pits which receive the mandibular teeth. The seventh and eighth are likewise separated by pits, but are farther from each other than are the teeth farther forward. All of the pits are in line with the teeth themselves. The eighth and ninth teeth are moderately far apart, but are not separated by pits. Posterior to the ninth the maxillary teeth are all very close together.

NASALS.—The nasal bones are short, occupying less than one-half the length of the skull, in spite of the fact that they extend farther forward than do most crocodilian nasals. Their anterior processes, which separate the superior level of the narial aperture into two separate cavities, are very slender; immediately posterior to the narial aperture, however, the nasals expand in breadth very rapidly, and reach their maximum breadth at the points where the premaxillaries, maxillaries, and nasals come together. From these points, which are at the level of the third maxillary teeth, backward, the nasals remain constant in breadth, their lateral boundaries (the maxillo-nasal sutures) being parallel. Posterior to the ends of the maxillo-nasal sutures, at the level of the seventh maxillary teeth, the nasals decrease in breadth, and end rather abruptly at the level of the ninth maxillary teeth. Their posterior borders are nearly transverse. The sutures of the nasals with the lacrymals are slightly longer than their sutures with the prefrontals.

LACRYMALS.—The lacrymals are large. They contain the tuberosities anterior to the orbits which were noted above. Each of them occupies about twice as much area as the corresponding prefrontal; their sutures with the prefrontals, and their axes of greatest length are very oblique in position.

PREFRONTALS.—The prefrontals are of moderate size. Their postero-external borders (the orbits) and their antero-external borders (the lacrymo-prefrontal sutures) are symmetrical with each other; their internal borders (the naso-prefrontal sutures and prefronto-frontal sutures) form symmetrical, gently concave lines. Their sutures with the nasals are very short.

FRONTAL.—The median frontal bone is relatively large. Its anterior process is unusually short in proportion to the size of the large posterior plate. The anterior process is relatively broad, and it ends rather abruptly at its anterior end, not wedging the two nasals apart as in most crocodilians. The orbital borders of the frontal are sharply uprolled;

the interorbital space is relatively narrow. The posterior portion of the frontal, posterior to the level of the posterior ends of the orbits, is relatively long antero-posteriorly, and is flat.

POSTORBITALS.—These bones are small. Each of them occupies about two-fifths as much area on the cranial table as the corresponding squamosal. Each occupies about three-tenths of the lateral border of the cranial table; the lateral border, and anterior, or orbital border, of each are approximately equal in length.

SQUAMOSALS.—The squamosal bones are large. Each squamosal occupies about two and one-half times as much surface area as the prefrontal of the same side, and about seven-tenths of the lateral border of the cranial table; its surface area is about equal to that of the parietal. The length of external border of each squamosal is only slightly greater than the length of its posterior border; each squamosal comprises a larger portion of the posterior border of the cranial table than the parietal and supraoccipital together. The squamosals are not elevated at their postero-external angles, nor are they characterized by unusual pitting, except that some of their pits are somewhat deeper than those of other parts of the cranial table.

SUPRAORBITALS.—The supraorbital bones, or bony eyelids, are unusually large, and are considerably curved. The one on the right side appears to be composed of several separate elements which are united to each other by suture. This may be partly accidental, however, although at least one of the cracks appears to be a true suture.

PARIETAL.—The parietal is very flat and is very regularly pitted, except immediately around the supratemporal fenestræ, where it is smooth. Its central portion is very broad, in connection with the wide spacing of the fenestræ. It occupies about two-thirds of that portion of the posterior border of the cranial table which is situated between the internal boundaries of the squamosals. The supraoccipital occupies the median third, while the parietal embraces it on either side, and forms the two external thirds.

SUPRAOCCIPITAL.—The supraoccipital occupies a very small portion of the surface of the cranial table, and occupies a small portion of its posterior border, as noted above. On the posterior surface of the skull it occupies over one-third of the breadth of the cranial box, at its broadest point, and it extends downward about two-thirds of the distance from the superior border to the foramen magnum; this last character may be correlated with the young age of the individual.

EXOCCIPITALS, BASIOCCIPITAL, BASISPHENOID, AND QUADRATES.—These bones are not sufficiently characteristic to deserve special attention.

QUADRATO-JUGALS.—These bones are broad at their posterior ends, and are slender farther forward. The right quadrato-jugal of the specimen studied extends into the infratemporal fenestra as a sharp process, comparable to those of the various species of *Crocodylus*, and of *Tomistoma*, but somewhat smaller. The left side has no such process, but it may have been present and broken off. The Gray-Schmidt figures indicate no such processes on the specimen figured.

JUGALS.—The jugal bones are characterized by their relatively great vertical, and short antero-posterior diameters. Their posterior processes are especially short.

PALATINES.—The sutures of the palatines with the maxillaries have been described above. Posterior to these sutures the palatines decrease in breadth very rapidly, until at the level of the eleventh maxillary teeth, or perhaps the level of the borders of the tenth and eleventh maxillary teeth, they are about one-half their breadth at the level where the maxillo-palatine sutures enter the fenestral borders. From the constricted portion backward the palatines broaden very rapidly, until at their sutures with the pterygoids they are broader than at their anterior ends. They are also somewhat expanded vertically at their posterior ends, assisting the pterygoids in enclosing an enlargement of the nasal passage. The transverse suture of the palatines with the pterygoids is situated altogether anterior to the posterior ends of the palatine fenestræ. This suture extends across the interfenestral plate in an irregular, though almost-directly transverse, direction. Near the fenestra, however, on the left-side of skull, the suture makes a sharp turn forward, and then turns sharply backward again. The irregularities are all on a very small scale—however, and the suture is nearly transverse.

PTERYGOIDS.—The pterygoids are relatively long in proportion to their breadth, as compared with other crocodiles. The small internal narial aperture occupies only a small portion (about one-fifth) of the antero-posterior diameter on the median line. The two pterygoids are united by suture ventrally, but are united without suture superiorly. The pterygoids extend forward beyond the posterior ends of the palatine fenestræ, and compose a portion of the interfenestral plate.

ECTOPTYRGOIDS.—These bones extend as far forward as the posterior margins of the tenth maxillary teeth; as noted above, they extend into the palatine fenestræ as short processes. Their posterior

cesses, therefore, are very broad, and are not pointed anteriorly. The inferior processes are very broad at their bases; their superior processes are small.

The Mandible

The mandible is broad, and is composed of stout bones. Each ramus has fourteen teeth, but also has a depression in the alveolar border posterior to the teeth, which might be occupied by a pair of teeth in an older individual. The posterior processes extend backward parallel to each other, instead of converging posteriorly, as in many other crocodiles. The external mandibular foramina are relatively large. The large posterior internal mandibular foramina are very large; anterior to these are pairs of small foramina, one very small, along the contacts of the dentaries and the coronoids, the other, at a lower level, and somewhat farther, along the contacts of the dentaries and angulars. The mandibular rami are slightly festooned. The symphysis extends back as far as the level of the fifth mandibular teeth. The splenial bones extend almost to the symphysis, reaching beyond the level of the sixth mandibular teeth. The internal walls of the alveoli of the thirteenth and fourteenth mandibular teeth appear to be composed of the splenial bones instead of dentaries.

The spaces between the mandibular teeth are all approximately equal, except for the spaces between the eighth and ninth, on each side, which are greater than those between the other teeth. The fourth is the first tooth on each side, and the eleventh is second in size. The first teeth on each side are sharp, while the last four are blunt; the transition from relatively long-crowned to relatively short-crowned teeth is very gradual.

Measurements Amer. Mus. No. 7743

Length of Skull, Tip of Snout to Supraoccipital	.1265M.
Length of Skull, Tip of Snout to Ends of Quadrates	.1315
Length of Snout	.0670
Depth of Snout at Base	.0560
Depth of Snout at Fifth Maxillary Teeth	.0475
Depth of Snout at Notches	.0280
Depth of Snout Across Premaxillaries	.0290
Depth of Skull Across Quadrato-jugals	.0778
Depth of Cranial Table	.0454
Depth of Interorbital Plate	.0122
Length of Right Orbit	.0300
Length of Left Orbit	.0290
Length of Mandible	.1485
Depth of Mandible	.0780

Remarks

This form is in some respects more highly specialized than *Osteoblepharon osborni*, especially in connection with the nasal septum, the irregularities of the palatine fenestræ, and the very small size of the supratemporal fenestræ. In other respects it is rather primitive, and resembles the Eocene crocodiles of the Bridger Epoch. It may be considered as a side line, which has diverged from the central crocodile stem in Tertiary time; *Osteoblepharon* is intermediate between this form and the true crocodiles; the species has no direct relation to *Alligator* or *Gavialis*.

JACARE Gray

GENERIC CHARACTERS

The species listed under this genus are sometimes included under *Caiman*, as in the catalogue by Boulenger. Certain writers, especially Huxley, have considered that the South American caimanoid species belong naturally in two genera instead of one. Three of the five species referred by Boulenger to *Caiman* are here referred to *Jacare* (*J. sclerops*, *J. latirostris*, and *J. niger*); the two remaining species (*C. trigonatus* and *C. palpebrosus*) are referred to *Caiman*.

The skull of this genus is broad, and is rounded at the anterior end; the fourth mandibular teeth typically bite into pits in the upper jaw as in *Alligator*. The prefrontal borders of the orbits are elevated into prominent ridges; these extend forward and slightly outward, over the lacrymal and maxillary bones; their strength and extent vary among the species. Near the anterior ends of the orbits the two ridges are connected by a transverse ridge, which in some cases is lower and narrower than the antero-posterior ridges; the transverse ridge is usually interrupted at the median line by a slight depression; it separates the lower surface of the snout from the upper surface of the interorbital plate; the anterior portions of the longitudinal ridges and the transverse ridge together frequently form a letter U in general outline. The supratemporal fenestræ are small, and in very old individuals are occasionally obliterated; they are situated far apart from each other. There may or may not be a constriction at the lateral border of the snout along the line of the premaxillo-maxillary suture. There is usually a slight constriction farther back. The cranial table is flat.

The orbits are large and close together. The narial aperture is also large, and is especially broad in proportion to its length. It is not divided by a median bony septum as in *Alligator*. The premaxillary foramen is large; it is very long in proportion to its breadth; it is

sharply pointed anteriorly, and may be pointed or rounded posteriorly. The palatine fenestræ are large. The internal narial aperture is very broad in proportion to its length; it is, usually at least, divided by a median septum.

One of the most characteristic and constant characters of the genus is the relation of the squamosal, parietal, and supraoccipital bones to each other. The supraoccipital occupies a considerable area on the surface of the cranial table; it occupies the entire portion of the posterior border of the table which is situated between the two lateral portions which consist of the squamosals; the PARIETAL IS THEREFORE EXCLUDED FROM THE POSTERIOR BORDER ALTOGETHER; this is a decided contrast with the condition in all other known crocodiles.

The lacrymal bones are large, and irregular in outline, especially along their anterior borders; they have extensive contacts with the nasals. The maxillo-palatine suture is characteristic and constant in outline. On each side it curves outward anterior to the palatine fenestra, then inward again to the median line. The anterior end of the two palatines together, is therefore rounded externally. The posterior ends are not distinctive.

Huxley includes in his diagnosis of the characters of this genus this statement: "The vomers [prevomers], separated by a longitudinal suture, appear in the palate between the premaxillaries and the palatine plates of the maxillaries." This statement will hardly hold for the entire genus, as in none of the specimens of *J. sclerops* and *J. latirostris* examined do the prevomers appear at the surface of the palate. They do so appear in *J. niger*, however, and their presence may be considered as a specific and not a generic character.

The teeth are stout, and the lower series bites entirely inside of the upper series. The fourth maxillary teeth are enlarged. The number of superior teeth on each side varies from eighteen to twenty; the number of inferior teeth also ranges from eighteen to twenty.

Jacare niger (Spix)

The following description of the skull of *Jacare niger* is based primarily upon a somewhat more than half-grown specimen in the Harvard Museum (Mus. Comp. Zool. No. 4043). Many of the characters were verified upon a full-grown specimen in the American Museum (Amer. Mus. No. 15171); this specimen is not complete.

General Form

In the general form of the skull *Jacare niger* resembles *J. sclerops* and *J. latirostris*; it differs somewhat from the other two species, however, and in some respects is intermediate between them.

The skull is relatively broad and short, as in the other two species of *Jacare*. The anterior end of the snout is slightly more pointed than in these species, especially *J. latirostris*. The outline of the snout suggests a triangular form, although it is not distinctly triangular.

The ridges of the snout are unusually prominent. They comprise two distinct groups, as in the two related species; they are far more prominent than in *J. sclerops*. The posterior group consists of the pre-orbital U-shaped elevations and the anterior group of a pair of oblique elevations which extend inward and backward, at angles of about 45° from the antero-posterior direction, from the position of the premaxillo-maxillary suture on the lateral borders of the skull, to points near the junctions of the premaxillo-maxillary, premaxillo-nasal, and maxillo-nasal sutures, and then directly backward, or backward and then slightly outward, and join the posterior U-shaped ridges immediately anterior to the junctions of the maxillo-nasal, maxillo-lacrymal, and naso-lacrymal sutures.

The posterior ridges rise on the superior borders of the orbits about midway between the anterior and posterior ends of the latter. They extend forward in almost straight lines to the areas above the fourth maxillary teeth, where they merge into the rounded elevations of the snout above these large teeth. The anterior half of the interorbital region, between the two ridges, is concave. The ridges themselves are very prominent; they diverge anteriorly and, not counting the transverse connecting ridge, resemble a V rather than a U. The connecting ridge is low; it is only very slightly elevated above the level of the interorbital region, but is distinctly elevated above the surface of the snout. At the median line the passage from the interorbital plate to the snout is gradual, the ridge being low, practically absent at this point. Either side of the median line the descent is very sudden, the snout being depressed immediately anterior to the transverse ridge. The two strong diverging ridges and the weaker transverse ridge together make a U-shaped structure, whose arms diverge much more than do those of *J. sclerops* or *J. latirostris*.

There is no prominent elevation around the external narial aperture, but there is a low ridge-like structure bordering the postero-external corner on either side.

The cranial table is rather small, and its surface is very flat. Its external borders are nearly parallel, though they converge very slightly in the anterior direction. The external borders are not sharply set off from the anterior borders, but merge into them through short antero-external borders at the antero-external angles of the cranial table. The posterior border of the table is strongly concave.

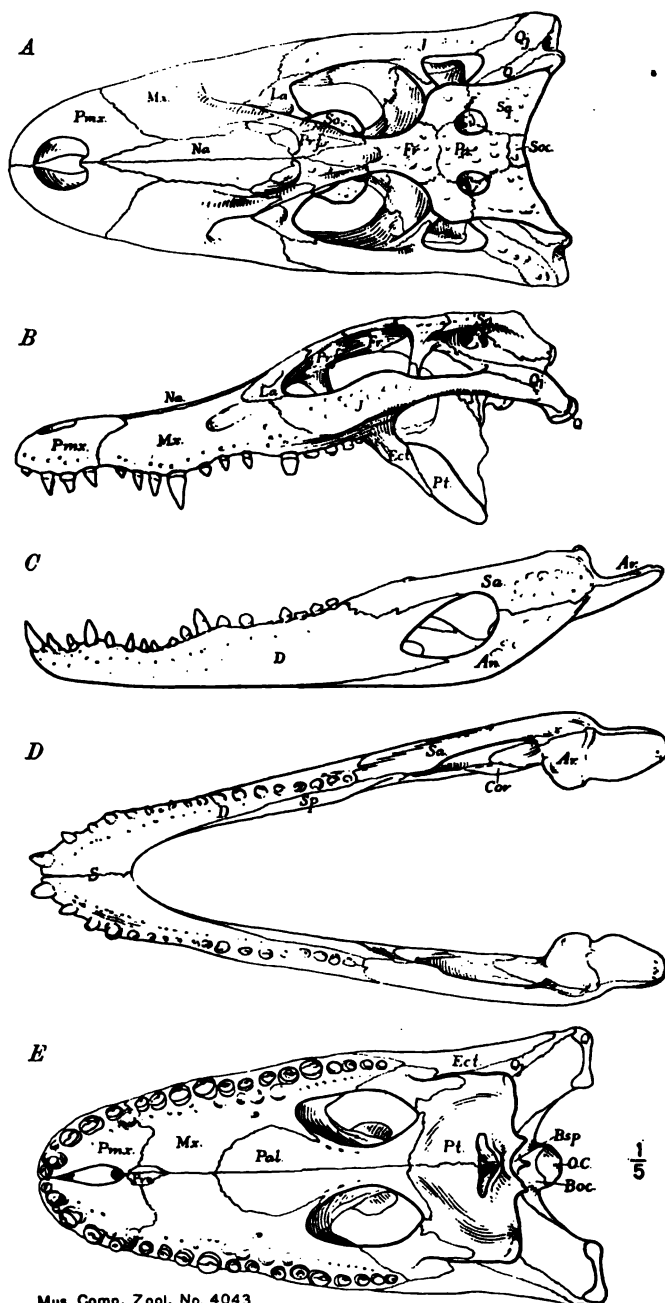
The Cavities of the Skull

SUPRATEMPORAL FENESTRÆ.—These cavities are small and are irregularly elongate in form, their greatest diameters being antero-posterior in direction. They are situated rather far forward on the cranial table, being nearer the orbits than the posterior border; they are also rather widely separated, the interfenestral space being considerably greater than the space between either fenestra and the external border. The two fenestræ together would be much smaller than the external narial aperture.

INFRATEMPORAL FENESTRÆ.—These fenestræ are small in size, though they are considerably larger than the supratemporal fenestræ. Each of them is distinctly triangular in form, with the three sides of the triangle approximately equal in length. The apex of each triangle lies under the anterior end of the corresponding supratemporal fenestra. The postorbital bar, which forms the anterior boundary of each infratemporal fenestra, is considerably more inclined than in most crocodilians including *J. sclerops*.

ORBITS.—The orbits are enormous in size, occupying one-fourth of the total length of the skull, from the extremities of the quadrates to the tip of the snout. They are also broad laterally, the interorbital space being narrow, especially in its posterior half. In form the superior, or internal, half of each orbit is regularly curved; the inferior, or external border is composed of two nearly straight lines of equal length, which meet below the center of the orbit. The huge size of the orbits is a striking characteristic of the species. Each orbit contains a small bony eyelid.

EXTERNAL NARIAL APERTURE.—This cavity is large, and is well separated from the tip of the snout. It is rounded anteriorly with a slight notch at the median line; its broadest point is nearer the anterior than the posterior end. The anterior portions of the lateral borders are rounded, and are not separable from the anterior border; the posterior portions are straight and converge slightly backward. The posterior border is straight and transverse, except at the median line, where there is a pair of processes from the premaxillaries projecting into the cavity itself.



Mus. Comp. Zool. No. 4043

Fig. 11. Skull and jaws of *Jacare niger* (Spix). Mus. Comp. Zool. No. 4043, one-fifth natural size. A, superior view of skull; B, lateral view of skull, left side; C, lateral view of mandible, left side; D, superior view of mandible; E, inferior view of skull.

PREMAXILLARY FORAMEN.—This cavity is very large; it is elongate in form, and is pointed at each end, more acutely so at the anterior end than at the posterior. The lateral borders are straight converging lines in the anterior portions, but are more rounded near their posterior ends. The foramen extends from very near the first premaxillary teeth to the premaxillo-prevomer suture.

PALATINE FENESTRÆ.—The palatine fenestræ are large, but not unusually so; they are rather broadly rounded anteriorly and broadly pointed posteriorly. They are regular in outline, the external and internal borders being symmetrical with each other. They extend as far forward as the spaces between the eighth and ninth maxillary teeth.

INTERNAL NARIAL APERTURE.—This cavity is very broad in proportion to its length. Its anterior border is straight and transverse in direction; its posterior border is irregular, and is elevated into a pair of flanges which slightly overhang the cavity itself. The median bony septum is strong. The cavity faces forward as well as downward.

The Bones of the Skull

PREMAXILLARIES.—The premaxillary bones are broad in proportion to their length. In the smaller specimen examined they are pierced by the first and fourth mandibular teeth; in the larger specimen they are not pierced at all.

The premaxillo-maxillary sutures, on the superior surface, extend inward and backward, somewhat irregularly, but in a general direction about 45° from antero-posterior. The posterior ends of the bones lie over the third maxillary teeth. In the smaller specimen the premaxillaries meet behind the narial aperture, excluding the nasals from the latter; in the larger specimen they do not come in contact with each other superiorly, the nasals entering the aperture. The premaxillo-nasal sutures diverge rapidly in the posterior direction.

On the palatal surface each premaxillo-maxillary suture extends from the center of the space between the fifth premaxillary tooth and the first maxillary tooth, inward and slightly backward across the deep pit which receives the fourth mandibular tooth, across a small foramen internal to this pit, then backward and slightly inward to a point slightly posterior to the level of the first maxillary teeth, then obliquely inward and forward to the contact of the premaxillary, maxillary, and prevomer, from which point the suture extends obliquely, but not far from antero-posteriorly, forward to the median line as a premaxillo-prevomer suture.

The first premaxillary teeth are very small; the second are not preserved in either skull studied, but from their alveoli appear to have been small, but not much smaller than the first; the third are large and strong; the fourth are also large and stout, next to the fourth and ninth maxillary teeth being the largest in the upper jaw; the fifth are of medium size, being larger than the first and smaller than the third.

These teeth are spaced in the usual manner; the first are situated close together; they are separated from the second by the unusually large pits for the first mandibular teeth; the second are rather close to the third, but their alveoli are separated from those of the latter by stout walls of bone; the third and fourth, and the fourth and fifth, are separated by considerable, though not great, spaces of equal size.

MAXILLARIES.—Like the premaxillaries, the maxillaries are relatively broad. They contain most of the large preorbital ridges mentioned above, also the larger portions of the anterior oblique ridges.

The maxillo-nasal sutures diverge in the posterior direction, but not as conspicuously as the premaxillo-nasal sutures, throughout their entire lengths. The maxillo-lacrymal sutures are complex in form. Each of them extends forward and outward a short distance from its origin at the maxillo-naso-lacrymal contact over the space between the seventh and eighth maxillary teeth, then backward and slightly outward up on the preorbital ridge, to a point over the large ninth maxillary tooth, then outward and forward, down over the external margin of the preorbital ridge to a point opposite its origin, then backward and outward to a point near the anterior end of the orbit, over the ninth maxillary tooth, where the maxillary, lacrymal, and jugal bones come in contact with each other.

The maxillo-jugal suture extends almost directly downward, on each side, from the point just mentioned, for a distance about half that between this point and the inferior border of the skull, then curve backward to the posterior end of the maxillary bone.

On the palate the maxillaries occupy a comparatively small space because of the large size of the anterior processes of the palatines, and the presence of the prevomers at the surface. Neglecting the prevomers the distance along the median line from the premaxillaries to the palatine is not great, the anterior end of maxillo-palatine suture extending slightly farther forward than the level of the fifth maxillary teeth. As nearly one-half of this distance is occupied by the prevomers, the median longitudinal extension of the maxillaries is very small. The maxillo-palatine suture extends, on each side, inward and backward from near the anterior

end of the palatine fenestra in the usual crocodilian manner, then forward and outward to a point slightly posterior to the level of the seventh maxillary teeth, then curves forward and inward to the median line. At the level of the greatest lateral expansion of the palatines the maxillaries occupy but seven-twelfths of the total breadth of the skull.

NASALS.—The nasals are relatively short and broad bones. They are excluded from the external narial aperture in the smaller skull studied, but enter it in the larger one; in the smaller specimen the left nasal is longer than the right. The nasals broaden rapidly from their anterior extremities to the level of the anterior ends of the naso-lacrymal sutures, over the seventh maxillary teeth; from this point back they narrow gradually to the posterior ends of the naso-lacrymal sutures, then narrow rapidly to a point between the anterior ends of the orbits, immediately anterior to the transverse ridge. The sutures with the premaxillary and maxillary bones have been described above. The contacts with the lacrymals are very short, each being but one and one-half centimeters long in the smaller skull. The naso-prefrontal sutures are somewhat longer, but are still rather short; the nasals have no contact with the frontal in the smaller skull, but they are slightly wedged apart at their posterior ends by the anterior process of the frontal in the larger one. The total length of the nasals is about one-third of the total length of the skull.

LACRYMALS.—The lacrymals are moderate in size and complex in form. The maxillo-lacrymal and naso-lacrymal sutures have been described above. The lacrymo-prefrontal sutures are long, the lacrymal bones extending relatively far back on the superior borders of the orbits. The sutures with the jugals are short, being less than three centimeters long in the younger skull; these sutures rise from the inferior borders of the orbits slightly posterior to their anterior pointed extremities.

PREFRONTALS.—The prefrontal bones are long and slender. They occupy very short spaces along the centers of the superior borders of the orbits; in the smaller skull they meet each other along the median line posterior to the nasals. The prominent cross-ridge between the anterior ends of the orbits is borne entirely by the prefrontals.

FRONTAL.—The frontal is relatively long. As noted above, it has no contact with the nasals. It is narrow in its central portion, in connection with the huge size of the orbits. The posterior, or cranial, portion is also narrow; the bone does not extend far back of the posterior ends of the orbits.

The frontal is rather widely separated from the supratemporal fenestra. The sutures with the postorbitals are short, and are inclined about

45° with the longitudinal axis of the skull. The suture with the parietal is also short, and is nearly transverse in direction.

POSTORBITALS.—These bones are small. Their sutures with the frontal have been described above. The sutures with the parietal are short, and they make angles of about 45° with the longitudinal axis of the skull; they are nearly, if not quite, perpendicular with the longitudinal axis of the skull.

SQUAMOSALS.—The squamosal bones are very large, the surface area of each being about three times as great as that of the corresponding postorbital. They have extensive sutures with the supraoccipital, completely excluding the parietal from the posterior border of the cranial table. In this *J. niger* resembles *J. sclerops* more than *J. latirostris*. The sutures with the parietal and supraoccipital are nearly antero-posterior in direction, except near the posterior ends of the supratemporal fenestræ, where the squamoso-parietal sutures bend outward in the anterior direction.

PARIETAL.—The parietal bone is relatively large, in correlation with the small size of the supratemporal fenestræ. As noted above, the bone is excluded from the posterior border of the skull by the large superior plate of the supraoccipital.

SUPRAOCCIPITAL.—The supraoccipital bone is large. Along the posterior border of the cranial table it occupies the entire space between the two squamosals. The sutures with the squamosals are rather extensive, contrasting somewhat with those of *J. latirostris*. The supraoccipital portion of the posterior surface of the skull is also large; it extends vertically about two-thirds of the distance downward from the superior border to the foramen magnum.

EXOCCIPITALS, BASIOCCIPITAL, BASISPHENOID, AND QUADRATES.—These bones are not especially characteristic in outline or relations.

QUADRATO-JUGALS.—These bones are rather short and broad, and their borders are nearly parallel. Their antero-superior processes are relatively broad; they have smoother outlines than in *J. sclerops*.

JUGALS.—The posterior bars of the jugal bones are unusually slender and their anterior plates are high. The transition from slender to broad portion, in each, is sharp.

PREVOMERS.—*Jacare niger* is unique among the existing crocodilians in having the prevomers as part of the surface of the palate between the premaxillary and maxillary bones. They may sometimes be seen on the palate of *Tomistoma schlegelii*, but between the maxillaries and palatines. In *J. niger* the prevomers on the palatine surface appear as a small irregu-

rhomboid figure. In the smaller specimen studied they are unequal; this may vary among different individuals. These bones are not preserved in the larger skull. They extend from the posterior end of the inferior premaxillary foramen, slightly posterior to the level of the premaxillary teeth, back to the level of the second maxillary teeth.

PALATINES.—These bones are not preserved in the larger skull. In the smaller one they form nearly the entire internal borders of the palatine fenestræ. The sutures with the maxillaries have been described elsewhere. The anterior processes together occupy a large rounded area on the surface of the palate, as in *J. sclerops* and *J. latirostris*. The palatines extend back beyond the posterior ends of the palatine fenestræ. The bone with the pterygoids is shaped like a letter V, with the apex directed forward.

PTERYGOIDS.—The pterygoids are not preserved in the larger skull. In the smaller one they are very concave in form, both in the anterior and the transverse directions. They form very small portions of the external borders of the palatine fenestræ. Posterior to the internal apertures they are elevated into a pair of ridge-like processes.

ECTOPTERYGOIDS.—The anterior processes of the ectopterygoids are short, extending forward only to the level of the posterior borders of the eleventh maxillary teeth. Their superior processes are very short, their postero-inferior processes are both long and stout.

Mandible

The mandible is stout. The symphysis is of moderate length; in the smaller specimen it extends back to the level of the spaces between the fourth and fifth mandibular teeth; in the larger one it extends back to the level of the fifth mandibular teeth. In the larger specimen the dentals extend forward to the symphysial suture, but do not form any massive portion of the symphysis; in the smaller specimen the left dental extends forward to the symphysis, but the right one falls short.

The external mandibular foramina are very large; the internal ones are moderately large. The articular surfaces of the articular bones are crossed by small but distinct transverse ridges, dividing them into anterior and posterior portions. The posterior processes of the surangular and articular bones extend directly backward, and do not converge inward as in many crocodilians.

Each ramus of the mandible contains eighteen teeth. These vary considerably in size and form. The fourth, in each ramus, is the largest; the first is only slightly smaller. The eleventh and twelfth are also large.

From the fifth to the tenth, inclusive, the teeth are very small. The second and third are of median size, also those posterior to the twelfth. The anterior twelve or thirteen teeth are stout, but they are more or less sharp pointed, especially in the anterior region of the jaw. The posterior teeth are very blunt.

Measurements

	Mus. Comp. Zool. No.	Amer. Mus. No. 15171
	4043	
Length of Skull, Tip of Snout to Supraoccipital	.340M.	.455M.
Length of Skull, Tip of Snout to Ends of Quadrates	.374	.500
Length of Snout	.190	.270
Breadth of Skull Across Quadrato-jugals	.181	.268
Breadth of Snout at Base	.150	.197
Breadth of Cranial Table	.095	.145
Length of Left Orbit	.092	.110
Length of Mandible, Total	.417	....
Breadth of Mandible, Maximum	.200	.270

Jacare latirostris (Daudin)

The description of the skull of this species is based upon a single specimen (Mus. Comp. Zool. No. 4981).

General Form

The skull is exceedingly short and broad; the snout is especially so, its length and its breadth at the base being approximately equal. The anterior end of the snout is rounded, much as in *Alligator mississippiensis*. A very slight constriction marks the lateral portion of the premaxillo-maxillary suture. The cranial table is large, and is considerably broader than long; it is rather coarsely pitted, and it is convex in lateral profile; this last character may be due to the relatively young age of the specimen; it is approximately rectangular in outline.

The interorbital region is concave, the posterior portion of it only slightly so, the anterior portion deeply so. A conspicuous ridge constitutes each supraorbital boundary. Anterior to the orbit this ridge becomes very prominent; it extends forward and outward to a point over the fourth maxillary tooth, where it ends in a slight expansion. The two opposite ridges are connected near the orbits by a complex transverse bridge. This rises a short distance anterior to each orbit, branches off from the rostral ridge and extends inward and somewhat backward to a point slightly external to the mid-line, about on a level with the anterior

of the orbits. There it dies out as a prominent cross-ridge, and the mid-line constitutes an inclined path, connecting the lower of the snout with the upper level of the interorbital region. On the side it continues symmetrically to its termination in front of the . The posterior edge of this ridge is merely a very slight elevation of interorbital region (except near the mid-line); the anterior edge is very overhung.

The U-shaped ridge is therefore somewhat more irregular than in *J. ps.* The snout is very irregular in shape. Two low flat ridges extend forward, with a shallow depression between them; these ridges and depression are situated on the nasal bones exclusively. They disappear near the external narial aperture. At the level of the fourth maxillary is a pair of depressions between the prominent preorbital ridges and the low nasal ridges. In the vicinity of these depressions the snout is very pitted; between this pitted area and the orbits it is relatively smooth. A pair of shallow irregular ridges extends outward and forward to a point near each premaxillo-maxillary-nasal juncture, along the maxillo-maxillary suture. The posterior half of each lateral border of the external narial aperture is elevated and rugose.

The Cavities of the Skull

SUPRATEMPORAL FENESTRÆ.—The supratemporal fenestræ are small, and are irregular in outline. They are situated rather far apart from each other, and their boundaries are not elevated into ridges. They are angular in outline rather than rounded, and the two are unlike each other.

INFRA-TEMPORAL FENESTRÆ.—These cavities are small, and are distinctly triangular in outline. They are overhung by the edges of the cranial table.

ORBITS.—The orbits are large; their inferior borders are straight or nearly antero-posterior in direction. Their posterior borders are straight, and their antero-internal borders are distinctly rounded.

EXTERNAL NARIAL APERTURE.—This cavity is broader than long. The nasals enter it at its posterior end, and form a conspicuous projection into it. The premaxillary portions of the posterior border curve forward somewhat toward this median posterior process. The small foramina are caused by the piercing of the snout by the first mandibular teeth at the aperture at the level of the anterior end of the premaxillary process. At the anterior end of the aperture four very small foramina are situated on the floor near the median line.

PREMAXILLARY FORAMEN.—This cavity is shaped much as in *J. sclerops*. Its lateral borders are slightly concave curves; these meet anteriorly, giving the cavity a rather acute anterior termination. The posterior border is directly transverse except for a slight notch at the median line.

PALATINE FENESTRÆ.—The palatine fenestræ are broad themselves, and the space between them is also broad, especially at its anterior end.

INTERNAL NASAL APERTURE.—This cavity is short anteroposteriorly, and is broad in proportion to its length.

The Bones of the Skull

PREMAXILLARIES.—These bones are considerably broader than they are long. The premaxillo-maxillary suture on each side, on the superior surface, extends inward on each side, about two-thirds of its length in a direction more nearly transverse than longitudinal, then turns backward in a direction more nearly longitudinal than transverse. The extreme posterior extensions of these sutures, on the superior surface, terminate at the level of the spaces between the second and third maxillary teeth. On the palatal surface the premaxillo-maxillary suture is very nearly transverse in direction.

Each premaxillary contains five teeth, which are rather widely spaced from each other; the fourth of these teeth is the largest.

MAXILLARIES.—The maxillaries are short in proportion to their length. They carry the larger portions of the prominent preorbital ridges. The posterior border of each maxillary, on the superior surface, is more nearly transverse than antero-posterior in its inner portion; its outer portion, over half the vertical distance down from the orbit to the dental border, is more nearly antero-posterior than transverse. At its extreme posterior end this border again curves upward.

Each maxillary contains fourteen teeth, of which the fourth is the largest. All of the teeth are weak and short; posterior to the fifth they are very short. The spaces between the teeth are approximately equal, except that between the fifth premaxillary and the first maxillary on each side; the latter space is greater than the rest. The sutures of the maxillaries with the nasals are short.

NASALS.—These bones are short and broad. Their broadest portions are immediately anterior to the anterior ends of the naso-lacrymal sutures. The naso-lacrymal and naso-prefrontal sutures are approximately equal in length. The lateral borders of the nasals converge anteriorly, from the anterior ends of the naso-lacrymal sutures, in a

ial manner to the posterior ends of the premaxillo-nasal sutures. anterior ends of the lateral borders of the nasals, between the pre-laries, converge sharply. Posteriorly the two nasals are wedged by the broad blunt process of the frontal.

LACRYMALS.—The lacrymals are large, and their breadth is greater their length. The lacrymo-prefrontal sutures extend across the verse ridge near the anterior ends of the orbits. Half of each nasonal contact is along an anterior process of the lacrymal, and not the mass of the bone. The sutures with the jugals are in the position ng anterior prolongations of the inferior borders of the orbits.

REFRONTALS.—These bones are smaller than the lacrymals. Their es with the nasals are approximately equal in length to the nasonal sutures. The transverse ridge crosses the prefrontals, and is upted medially at the contact of the prefrontals and frontal.

FRONTAL.—The frontal is short antero-posteriorly. It comprises, anterior process, the bridge from the interorbital region to the . The anterior end of the process is in the form of a wedge, which ates the posterior ends of the nasal bones. The suture with the tal is in the form of a broadly open V; it is situated a considerable nce anterior to the supratemporal fenestræ.

POSTORBITALS.—These bones are small and subrectangular in out-

SQUAMOSALS.—These bones are large. Each occupies two-thirds of kternal border of the cranial table. The squamosals appear to come ntact with the supraoccipital at or near the posterior border of the al table. The contacts are not clear in the specimen studied.

PARIETAL.—The parietal forms a considerable portion of the anterior ll as the internal border of each supratemporal fenestra. The bone atively narrow. It forms no portion of the posterior border of the al table, but is separated from it by the broad supraoccipital. The is deeply pitted.

SUPRAOCCIPITAL.—This bone occupies a small triangular area on the ce of the cranial table as in other species of *Jacare*. On the posterior ce it extends downward from the superior border three-fourths of istance from this border to the foramen magnum.

QUADRATES.—These bones have rather broad articular surfaces, are not lower in position than the foramen magnum.

EXOCCIPITALS, BASIOCCIPITAL, AND BASISPHENOID.—These bones ot sufficiently distinctive in form to require special description.

QUADRATO-JUGALS.—The quadrato-jugals are small; they lack the sharp processes which characterize the quadrato-jugals of some crocodilians, but they have irregular borders, with projections which faintly suggest these processes. In this respect *J. latirostris* resembles *J. sclerops* rather than *J. niger*; in the latter species there are no suggestions of projecting processes on the quadrato-jugals.

JUGALS.—The contacts of the jugals with the lacrymals are very short; those with the quadrato-jugals are very irregular.

PALATINES.—The palatines of this species are very short and broad.

PTERYGOIDS.—The pterygoids form but very small portions of the borders of the palatine fenestræ.

ECTOPTERYGOIDS.—These bones are very short and stout. Their sutures with the maxillaries extend as far forward as the level of the spaces between the tenth and eleventh maxillary teeth.

Mandible

The mandible is very short and broad. The symphysis is short, extending only slightly farther back than the level of the third mandibular teeth. The splenial bones extend almost to the symphysis. The dentaries are very shallow vertically in their anterior portions. The articular bones are very broad and stout.

The right ramus of the mandible contains eighteen teeth and the left one nineteen, in the specimen studied. None of the teeth are very large. Except that the fourth are somewhat larger than the rest the teeth are nearly equal in size.

Measurements Mus. Comp. Zool. No. 4981

Length of Skull, Tip of Snout to Supraoccipital	.128M.
Length of Snout	.067
Breadth of Skull, Across Quadrato-jugals	.079
Breadth of Snout at Base	.062
Breadth of Snout Across Fourth Maxillary Teeth	.055
Breadth of Cranial Table, at Posterior End	.051 (est.)
Length of Mandible	.156

Remarks

This species is the most brachycephalic of the modern crocodilians. The breadth of the snout is approximately equal to its length, and the length of the snout is only very slightly greater than the distance from the anterior end of the orbit to the supraoccipital. The prominence of the preorbital ridges resembles that of *J. niger*. In some other respects, however, the species is nearer *J. sclerops* in form.

Jacare sclerops (Schneider)

The following description of the skull of *Jacare sclerops* is based upon a series of specimens of varying ages. They include the following: Mus. Comp. Zool. No. 5082, Amer. Mus. No. 5239, Mus. Univ. Mich. No. 53113, Mus. Univ. Mich. No. 53112, Mus. Comp. Zool. No. 5031, Amer. Mus. No. 15184; Amer. Mus. No. 15183. In addition to these a disarticulated skull, Amer. Mus. No. 15185, was used to verify some characters.

General Form

The skull of *Jacare sclerops* is broad in proportion to its length. It does not reach the excessive breadth which characterizes *J. latirostris*, however. The snout varies from one and one-sixth to one and two-fifths as long as broad at the base. The anterior ends of the orbits are situated nearer the posterior than the anterior end of the skull in old individuals; in young individuals they are about equally distant from the two ends of the skull. The length of the skull from the extremities of the quadrates to the anterior ends of the orbits is from four-fifths to five-sixths the length of the snout in large individuals. The snout is moderately broad at the end and lateral to the external narial aperture; in most specimens it retains this breadth to the level of the first maxillary teeth; in a few it broadens gradually from its anterior end. From the level of the first maxillary teeth to that of the fourth the snout broadens rapidly; posterior to this is a slight constriction, which is most noticeable at the level of the spaces between the fifth and sixth maxillary teeth; from this point back the skull broadens steadily. The amount of vertical festooning of the inferior borders of the skull is slight compared with that in the true crocodiles. On each side a vertical notch extends from the fourth premaxillary to the third maxillary tooth; this notch is deepest between the fifth premaxillary and the first maxillary teeth, opposite the pit which receives the fourth mandibular tooth. The third and fourth maxillary teeth of each side are situated on a convexity of the jaw; back of this is a shallow excavation which reaches its maximum depth between the sixth and seventh maxillary teeth. Posterior to this excavation is a slight convexity, which extends back beyond the dental series. Immediately below each infratemporal fenestra is another slight excavation, posterior to which the inferior border of the skull descends slightly to the distal extremity of the quadrate. None of the above-mentioned irregularities in the vertical contour of the inferior borders of the skull are very pronounced.

The snout, and in fact the whole skull, is relatively low in proportion to its breadth, contrasting strongly with *Caiman trigonatus*. The superior surface of the snout is distinctly concave antero-posteriorly, and nearly flat, with rounded lateral margins, forming a sharp contrast with the angular margins of the snout of *Caiman trigonatus*.

The external narial aperture is almost surrounded, except at the anterior end, by a conspicuous ridge of bone; this character accentuates the upturned appearance of the snout.

In most of the skulls the first mandibular teeth pierce the premaxillaries, and in some the excavations are confluent with the narial aperture. The superior surface of the skull is slightly elevated above the pits which receive the fourth mandibular teeth; in a few cases the skull is completely pierced at this point, the foramen being either in the premaxillary or on the premaxillo-maxillary suture. Over each of the fourth maxillary teeth is a swelling; this is sometimes rather inconspicuous in young individuals, but is prominent in old ones.

Anterior to the orbits, and slightly internal to the median lines of the separate orbits, is a pair of slightly elevated ridges which extend a short distance forward on the snout. Posteriorly each ridge curves inward and meets the other, forming an inverted U. At the juncture of the two sides of the U a low, more or less indistinct ridge extends forward. The snout is distinctly separated from the interorbital region by the base of the U. The snout is distinctly lower in level than the interorbital region, the latter merging into the U so far as level is concerned. The interorbital region is deeply concave, the inner borders of the orbits being elevated into ridges which unite with the base of the U, and are continuous with the arms of the U.

The cranial table is relatively large, and is subquadrangular in outline; it is broader than long, and is relatively flat, although in some individuals it is very slightly convex laterally. It is relatively low in position, contrasting in this respect with *Caiman trigonatus*. The space between the two supratemporal fenestræ is relatively broad, being considerably broader than the space between the orbits.

The Cavities of the Skull

SUPRATEMPORAL FENESTRÆ.—The supratemporal fenestræ are relatively small in most of the individuals studied, and in one old one they are absent altogether at the surface, having been roofed over by the surrounding bones. In general they are larger in the younger individuals and smaller in the older ones, but there are slight variations from this

rule. In form these fenestræ are irregularly oval, and their greatest length diverge anteriorly away from the median line of skull.

are very small size, and in one case the complete obliteration, at the , of these cavities suggests that the species is undergoing the process of their elimination. In this particular character *J. sclerops* appears more progressive than *J. niger*. The process of elimination of the æ has not been accelerated to the same extent as in *Caiman* *latus*, however.

FRATEMPORAL FENESTRÆ.—These openings are small; in form they resemble a trianguloid figure with nearly equal straight sides and a curved base.

ORBITS.—The orbits are notably large in size, but not to the extreme of *J. niger*. In length each orbit varies from about one-fourth of total length of the skull in very young individuals to about one-sixth in old ones, the average being about one-fifth. The superior boundary of orbit is nearly semicircular; the inferior border is a gentle curve. There is a suggestion of an anterior point in each orbit, but it is not very pronounced.

INTERNAL NASAL APERTURE.—This opening is relatively large; it suggests a suggestion of a median partition, although the nasal bones enter at the posterior end in a short process. It is rather characteristic in form. Its straight lateral boundaries converge slightly toward each other in the posterior direction. Anteriorly the cavity is bounded by a straight border, which in old individuals is sometimes irregularly transverse. Posteriorly it is bounded by the small triangular extension of the process and a small notch on either side of that process. The anterior border is sometimes pierced, in some specimens, by the first mandibular teeth. In young skulls the aperture is slightly longer than broad; in old ones it is broader than long.

MAXILLARY FORAMEN.—This cavity is relatively large in young individuals and small in old ones. It is very narrow in proportion to its length; it is acutely pointed anteriorly, and broadly rounded posteriorly. In old individuals, especially old ones, there is a slight median projecting process forward into the cavity at the posterior end.

PALATINE FENESTRÆ.—The palatine fenestræ are simple in form and relatively large in size; they are one-fifth as long as the whole skull, from the tip of the snout to the extremity of the condyle. Their internal boundaries are rather gentle and symmetrical curves, mostly on the edges of the palatine bones, but partly on the maxillaries as well. The anterior

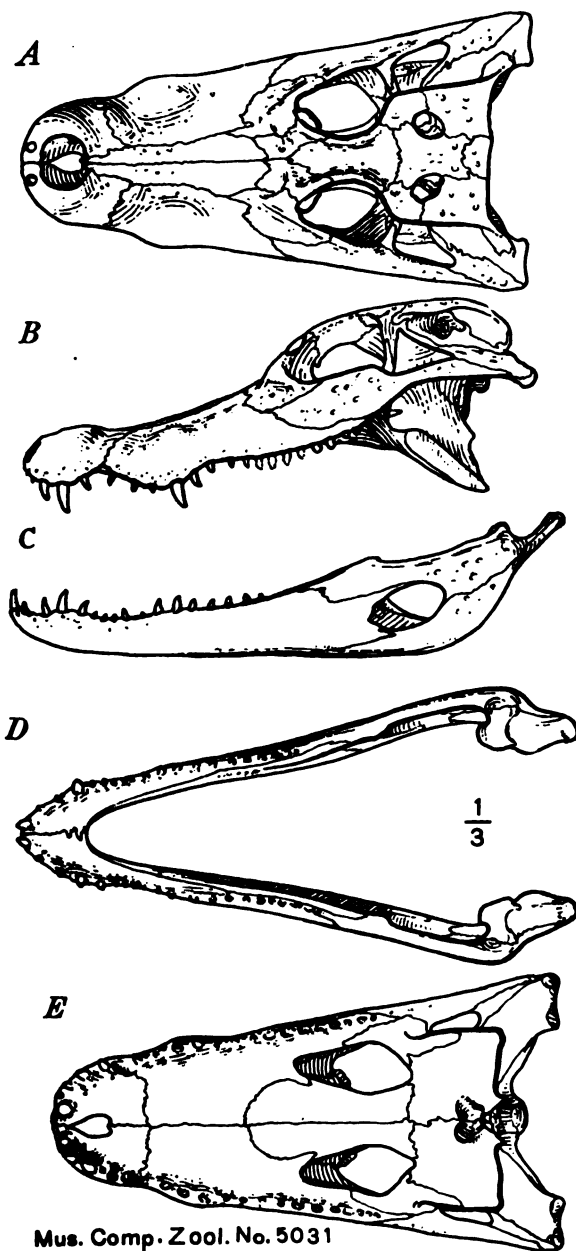
ends are more or less symmetrically rounded; the posterior ends are usually pointed, but not sharply so; the posterior terminations are internal to the median lines of the fenestræ. A small portion of the posterior border of each fenestra is bounded by the pterygoid bone; in some individuals, especially old ones, the pterygoid border of the fenestra is exceedingly small. The external border is sharply bent; the anterior portion of it, which is composed of edges of the maxillary and ectopterygoid bones, comprises from two-thirds to four-fifths of the length of each fenestra; this anterior portion lies parallel to the external wall of the skull. The posterior portion of the external wall of each fenestra is composed of an edge of the ectopterygoid. This border is oblique in position, sometimes being more strictly posterior than external.

INTERNAL NARIAL APERTURE.—The internal narial opening, situated near the posterior ends of the pterygoids at their median line, is broader than long. It is divided by a median partition, which usually does not reach the surface of the palate. A pair of projections of the pterygoids form the posterior boundary of the cavity, and in some cases partially roof it over.

The Bones of the Skull

PREMAXILLARIES.—The premaxillaries are broader than long in both young and old individuals. In some skulls the two premaxillaries are separated behind the narial aperture by the nasal bones; in other skulls, especially the older ones, the premaxillaries roof over the anterior ends of the nasals, and exclude them from the aperture. Anterior to the aperture the premaxillaries are pierced by the first mandibular teeth in some cases, and in others they are not. There is no apparent system to this piercing; it is present or absent in old individuals and young, large and small, narrow and broad, in about equal numbers.

The premaxillo-maxillary suture is more nearly transverse than longitudinal on the superior aspect of the skull. The posterior processes of the premaxillaries are broad; they do not extend back as long wedges between the nasals and the maxillaries as in some crocodiles. The posterior extremities of these processes is never farther back than the level of the third maxillary teeth. In most cases they are only slightly posterior to the level of the second maxillary teeth, and in one specimen (Mus. Comp. Zool. No. 5031) they are anterior to the level of the second maxillary teeth.



Mus. Comp. Zool. No. 5031

Fig. 12. Skull and jaws of *Jacare sclerops* (Schneider). Mus. Comp. Zool. No. 5031, one-third natural size. *A*, superior view of skull; *B*, lateral view of skull, left side; *C*, lateral view of mandible, left side; *D*, superior view of mandible; *E*, inferior view of skull.

On the palatal surface of the skull the suture between the premaxillaries and the maxillaries usually curves outward and backward on each side from the median line, and then curves forward and outward to the center of the pit which receives the fourth mandibular tooth. In some cases the loops formed by the backward curves are very slight, the suture being nearly transverse; in most of the skulls studied they extend back as far as the middle of the spaces between the first and second maxillary teeth; in one old skull they extend back as far as the level of the centers of the second maxillary teeth.

The first premaxillary teeth are small and are very close together. The second teeth are rather widely spaced from the first; they are small in size; one skull (Amer. Mus. No. 15184) has a distinct right second premaxillary tooth, but no left one or alveolus for one. The large pits which receive the first mandibular teeth are situated between the first and second premaxillary teeth, but internal to them rather than in line with them. The second and third teeth are close together. The third and fourth, and the fourth and fifth are about equally spaced, being closer together than the first and second, and farther apart than the second and third. The fourth tooth is the largest in each premaxillary, and the third is second in size; the fifth is slightly larger than the first. This order of size is not always apparent, as the size of the particular teeth is determined partly by their individual age; the size of the alveoli, however, is a true guide to the maximum sizes. All of the premaxillary teeth are sharp-pointed and relatively slender; they are slightly curved, and are somewhat flattened. The crowns are faintly striated.

MAXILLARIES.—The maxillaries are relatively broad on the superior surface of the skull, occupying about three-fourths of the total width of this surface. In this character *J. sclerops* contrasts rather sharply with *Caiman trigonatus*. Their length is about one-half the total length of the skull. The premaxillo-maxillary suture has been described above. The maxillo-nasal suture is very short in proportion to the total length of the maxillary bones. The maxillo-lacrymal suture, on each side, is irregular in form, but its form is uniform among all of the skulls examined. It extends a short distance backward and very slightly outward from the posterior end of the maxillo-nasal suture, then extends obliquely outward, downward, and backward to the point of contact of the maxillary, lacrymal, and jugal bones; this point lies over the tenth maxillary tooth.

The suture of each maxillary with the corresponding jugal varies somewhat in form. In some cases its upper portion is more nearly transverse than the postero-external portion of the maxillo-lacrymal suture,

others it is in a direct line with the latter. Its lower portion terminates on the inferior border of the skull, only very slightly anterior to the anterior end of the palatine fenestra on the palate.

The longitudinal extent of the maxillaries along the median line, on the premaxillary and palatine bones, is very slight. Nearly half of the external border, and in some specimens a considerable portion of the internal border of each palatine fenestra is composed of the alveary bone. The maxillo-palatine suture is slightly variable in form, never departs far from the typical *Jacare* outline. It usually extends outward and inward from a point near the anterior end of the internal border of the palatine fenestra, then extends forward, and usually out to a point opposite or slightly anterior to the end of the fenestra, curves gradually inward and meets the median line nearly at a right angle; from this point it extends in a symmetrical direction on the opposite side. The union with the opposite suture lies opposite the eighth maxillary teeth, or very slightly anterior to this level. The maxillo-ectopterygoid suture, on each side, extends as far forward as the eleventh or twelfth maxillary tooth.

The maxillary teeth increase regularly in size from the first, which are very small, to the fourth, which are the largest teeth in the superior jaw.

Posterior to the fourth the maxillary teeth are all small. In the first six or possibly seven maxillary teeth resemble the premaxillary teeth. The eighth, and in some cases the seventh, maxillary teeth are acutely pointed. Posterior to the eighth all of the maxillary teeth have small, blunt, and more or less elongate crowns, which are adapted for chewing than for holding or piercing prey. All of the maxillary teeth except the sixth and seventh, and the seventh and eighth, meet together; between these teeth are relatively broad spaces.

NASALS.—The nasal bones are characteristic, yet variable, in form. They usually enter the external nasal aperture, but are excluded from it by the premaxillaries in some cases. They expand rapidly in breadth toward their anterior ends back to the points where they are met by the maxillo-maxillary sutures; from these points they expand gradually back to the points at which the maxillo-lacrymal sutures join the maxillo-nasal sutures. From there back they contract rapidly, and have only a narrow contact with the frontal; the latter does not enter between the two nasal bones in a long wedge, as in many crocodiles. The contact with the lacrymals are relatively long; in some skulls they are longer than the naso-prefrontal sutures, and in others they are shorter.

LACRYMALS.—The lacrymal bones are relatively large in size, being considerably larger than the prefrontals. Each lacrymal forms the entire anterior boundary of the orbit, and a considerable portion of the inferior boundary as well. The contacts with the maxillaries and nasals have been described above. The suture of each lacrymal with the prefrontal extends directly, or slightly obliquely, backward from the nasal as far as the rounded junction of the base and side of the U-shaped ridge described above, then it usually curves almost directly outward to the superior border of the orbit. In one young skull (Amer. Mus. No. 5239) the lacrymo-prefrontal sutures are nearly antero-posterior throughout their entire lengths. The sutures with the jugals are long and rather symmetrically curved, the convexity of the curves facing downward. The lacrymals carry the lateral arms of the U-shaped ridge.

PREFRONTALS.—These bones are relatively small. Their most conspicuous feature is their common possession of the base of the U-shaped ridge. Their contacts with the nasals and lacrymals have been described above. The sutures with the frontal are short; they are also somewhat variable in form.

SUPRAORBITALS.—The supraorbital bones, or bony supports of the eyelids, are small, occupying only small portions of the orbits or of the borders.

FRONTAL.—The single frontal bone is not especially characteristic in form. Its suture with the parietal is situated considerably anterior to the supratemporal fenestræ; in some skulls it is almost transverse, and in others it is V-shaped. The supraorbital edges of the frontal are prominently uprolled.

POSTORBITALS.—These bones are not especially characteristic in the typical skulls. In the large skull in which the supratemporal fenestræ are closed the postorbital bones are nearly rectangular in outline.

SQUAMOSALS.—The squamosal bones are rectangular in form like the postorbitals. They are characteristic in that each has a considerable contact with the supraoccipital, excluding the parietal from the posterior border of the skull; the squamoso-supraoccipital sutures are long, as in *J. niger*; in this they differ slightly from those of *J. latirostris*.

PARIETAL.—The parietal is relatively large, owing to the small size of the supratemporal fenestræ. Its suture with the supraoccipital is as long as either of its sutures with the squamosals. This parieto-supraoccipital suture is V-shaped in young individuals and transverse in old ones.

SUPRAOCCIPITAL.—This bone is large. It occupies about one-fourth of the posterior border of the cranial table, also a considerable area of the side of the table. Its posterior surface extends down nearly three-fourths of the distance from the superior border to the foramen magnum. Its posterior surface is distinctly triangular in outline.

QUADRATES.—The quadrates are distinctive only because of the irregularities of their borders.

EXOCCIPITALS, BASIOCCIPITAL, AND BASISPHENOID.—These bones are not sufficiently characteristic to require special description.

QUADRATO-JUGALS.—The quadrato-jugals have very irregular contacts with the quadrates. Their posterior portions are short and broad. Their anterior processes have suggestions of the sharp processes of the pterygoids and are well developed in the true crocodiles.

JUGALS.—The anterior processes of the jugals are very much greater than their vertical diameters than the posterior bars. The extent of this difference is their only noteworthy characteristic.

PALATINES.—The palatine bones are characteristic in outline. They have broad anterior portions, which extend forward as far as the sixth maxillary teeth, usually expand in breadth anterior to the middle of the anterior ends of the palatine fenestræ. The lateral expansion at the posterior ends of the palatines is slight in young individuals, but much greater in old ones.

The suture between the palatines and the pterygoids is situated anterior to the posterior ends of the palatine fenestræ in young skulls, farther back, often behind the fenestræ, in older ones. This suture is usually transverse in direction, with short antero-posterior external processes; in one old skull (Amer. Mus. No. 15183) the suture is more complex in outline. In this skull it extends a very short distance directly from the posterior end of each fenestra, then a short distance inward toward the median line, then turns and extends obliquely forward and outward a considerably greater distance to the median line. The two palatine bones together, in this skull, are shaped like a Y, with the very broad base directed forward, and the short arms directed backward.

PTERYGOIDS.—The pterygoid bones are relatively broad in proportion to their length. In young individuals they occupy appreciable portions of the posterior borders of the palatine fenestræ, but in old ones they are almost excluded from the borders of these openings. The posterior external corners do not project far behind the level of the posterior border of the median line, and the posterior portions make a broad open contact with each other vertically.

ECTOPTERYGOIDS.—These bones are rather short antero-posteriorly; they extend as far forward as the eleventh maxillary teeth.

The Mandible

The mandible is short and stout in appearance. The symphysis extends back only to the level of the fourth mandibular teeth, or very slightly farther back in a few cases. In some specimens the splenial bones extend forward to the symphysis, but do not take part in the median symphyseal suture; in other specimens the splenials end a considerable distance back of the symphysis. The splenial bones themselves are stout; they comprise the inner alveolar walls of the last six mandibular teeth on each side. The articular surfaces of the articular bones are separated into anterior portions by oblique ridges; the posterior processes extend directly backward. The external mandibular foramina are large; the internal ones are of moderate size. The very small foramina which are present on the surfaces of the mandibles, between the splenial and coronoid bones, in most crocodilians, are absent in this species. The jaw is considerably festooned, especially in the older individuals.

Each ramus contains from eighteen to twenty teeth. Of these the fourth is the largest, as usual, and the first next in size. The eleventh and twelfth are only slightly smaller than the first. The fifth to tenth mandibular teeth, inclusive, are very small. The second and third are of medium size. All of the teeth posterior to the twelfth are small. The anterior teeth are sharp, and the posterior ones are blunt; the division line between blunt and sharp teeth is not sharply marked, but it is in the vicinity of the twelfth or thirteenth teeth. The spacing of the teeth varies considerably among the various specimens studied. The anterior three or four are usually far apart, and the posterior ones are close together. The teeth in the middle of the series are sometimes close together and sometimes widely spaced. This spacing also varies on opposite sides of the same specimen. Two of the specimens show a remarkable grouping of several of the teeth. In these specimens the seventh and eighth teeth are situated very close together, and are also inclined toward each other; they therefore act as a single tooth; the same is true of the ninth and tenth. This condition is more pronounced in the larger of the two specimens (Mus. Univ. Mich. No. 53112) than in the smaller one (Mus. Univ. Mich. No. 53113). This curious character is present only in the two specimens noted. Both of these specimens came from the same locality, and it is very probable that this grouping of the teeth is to be interpreted as a form of geographic variation.

Measurements

	Mus. Comp. Zool.	Amer. Mus.	Mus. Univ. Mich.		Mus. Comp. Zool.	Amer. Mus.	
	No. 5082	No. 5239	No. 53113	No. 53112	No. 5031	No. 15184	No. 15183
Length of Skull, Tip of Snout to Supra-occipital	12.55cm.	13.35cm.	14.9cm.	18.7cm.	18.75cm.	19.6cm.	24.8cm.
Length of Skull, Tip of Snout to Ends of Quadrates	13.5	14.4	15.8	18.8	19.9	21.0	27.3
Length of Snout	6.8(est.)	7.6	8.7	10.6	11.1	11.6	15.0
Breadth of Skull, Across Quadrato-jugals	7.4	8.2	8.5	10.0	10.95	12.4	16.2
Breadth of Skull, Across Cranial Table	4.35	4.61	5.20	5.8	6.05	7.28	8.95
Breadth of Snout at Base	5.30	6.10	5.7	7.1	8.0	9.2	11.5
Length of Left Orbit	3.00	3.20	3.3	3.6	3.9	3.8	4.8
Length of Mandible, Total	15.60	16.20	17.2	20.9	22.45	24.2	31.1
Breadth of Mandible, Maximum	.....	8.2	8.4	10.4	11.2	11.8	16.9

CAIMAN Spix**GENERIC CHARACTERS**

The skull of this genus is without transverse ridges; it is moderately long, and is subacuminate in outline. The skull is sharply angulated anterior to each orbit; the snout thus consists of three more or less distinct planes. The supratemporal fenestræ are obliterated, even in young individuals. The external narial aperture is undivided. The premaxillary foramen is approximately equal in length and breadth in *C. trigonatus*, differing from all the species of *Jacare*; probably *C. palpebrosus* resembles *C. trigonatus* in this respect. The fourth mandibular teeth bite into pits in the upper jaw, and all of the mandibular teeth bite inside the line of the upper teeth. Each premaxillary contains four teeth, and each maxillary fifteen or sixteen; the third and fourth maxillary teeth are the largest. Each ramus of the mandible contains from twenty to twenty-two teeth. The upper eye-lids are entirely bony. A number of characters through which *C. trigonatus* differs considerably from the species of *Jacare*, but which have not been verified on *C. palpebrosus*, include the following: parietal bones forming considerable portions of the posterior border of the cranial table, the supraoccipital being very narrow on its superior surface; vertical height of the cranial region considerable; anterior processes of the palatines considered together as one process rectangular in outline; very large external mandibular foramen; probably these will apply to *C. palpebrosus*, but they need verification in that species. The quadrato-jugals lack the anterior processes which are characteristic of *Gavialis*, *Tomistoma*, and *Crocodylus*.

***Caiman trigonatus* (Schneider)**

The description of the skull of *Caiman trigonatus* is based upon single young specimen (Mus. Univ. Mich. No. 46113).

General Form

The general form of the skull is in close accordance with the specific name *trigonatus*. The whole skull, from the ends of the quadrates to the tip of the snout, when viewed from above, is seen to be triangular in outline. The snout is long, being about one and nine-elevenths times as long as broad at the base, and is rather acute at its anterior end. The lateral borders are very nearly straight when viewed from above, there being little in the way of lateral constriction; the amount of vertical festooning is also slight.

The cranial table is broad and flat; it is considerably elevated vertically; the height of the skull from the extremities of the pterygoids to the cranial table is about two-thirds of the breadth across the quadratojugs. The cranial table itself is large, measuring about five centimeters laterally, and three and six-tenths centimeters longitudinally along the external border. In shape it is nearly rectangular. Anterior to the orbits the superior longitudinal profile of the snout is concave; the base of the snout is elevated. The transverse profile of the snout is unusual in the modern *Crocodilia*. The central half of the snout is flat, except for a slight median depression. In front of each orbit is a pronounced ridge, which separates the central flat portion from a very highly inclined lateral portion. Immediately below the ridge this lateral slope is nearly vertical, but at a lower level it becomes less highly inclined; near the inferior border it again becomes nearly vertical. The profile of the side of the snout, below the ridge which separates the side from the superior surface, is therefore concave above and convex below. These distinct planes on the sides of the snout become less pronounced farther forward. A prominent elevation is situated above each fourth maxillary tooth. Slightly posterior to the premaxillo-maxillary sutures, but more oblique in position than these, is a pair of short low ridges. The sides of the narial aperture are elevated, but the anterior and posterior ends are low.

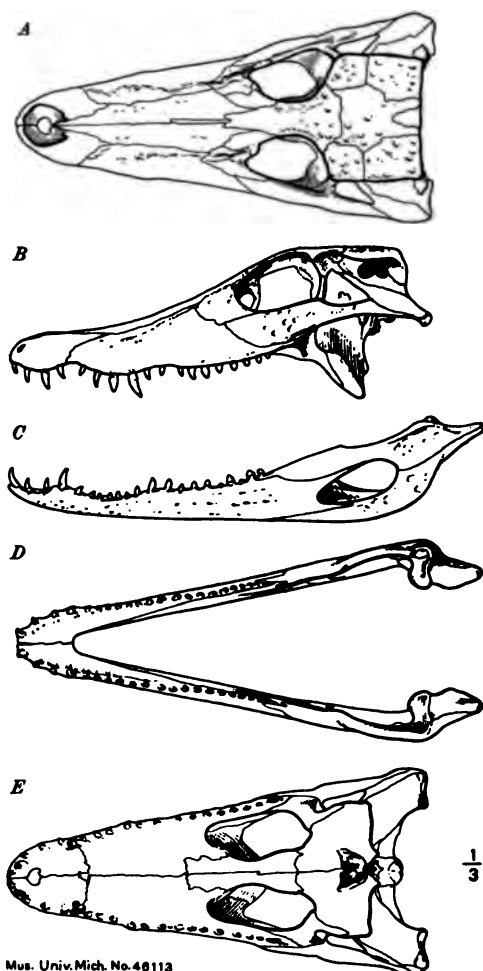
The Cavities of the Skull

SUPRATEMPORAL FENESTRÆ.—The supratemporal fenestræ are absent on the surface of the cranial table, having become secondarily closed. They are present in a vestigial condition in the form of a pair of tubular excavations extending back from the orbits over the external auditory meati.

INFRATEMPORAL FENESTRÆ.—These cavities are moderate in size. They are triangular in outline, with the anterior borders nearly vertical, the inferior borders horizontal, and the postero-superior borders oblique in position.

ORBITS.—The orbits are large, and are not bordered superiorly by upturned edges. The length of each orbit is about one-fifth of the total length of the skull. The superior border of each orbit is semicircular in outline, and the inferior border is nearly straight. The anterior end is not acuminate as in many crocodilians.

EXTERNAL NARIAL APERTURE.—This cavity is large. The posterior two-thirds of the lateral borders converge in the posterior direction; the anterior thirds converge more sharply in the anterior direction,



Mus. Univ. Mich. No. 46113

Fig. 13. Skull and jaws of *Caiman trigonatus* (Schneider). Mus. Univ. Mich. No. 46113, one-third natural size. A, superior view of skull; B, lateral view of skull, left side; C, lateral view of mandible, left side; D, superior view of mandible; E, inferior view of skull.

joining the nearly transverse anterior border not far from the median line. The small foramina which receive the first mandibular teeth enter the narial aperture.

PREMAXILLARY FORAMEN.—This opening is small; it contrasts with the corresponding foramen in *Jacare*, in having its breadth as great as its length. It is pointed anteriorly, but not sharply so. Laterally it

ded; its greatest breadth is nearer the posterior than the anterior

The posterior border is largely occupied by a broad shallow notch.

PALATINE FENESTRÆ.—The palatine fenestræ are large. They are at one and one-third times as long as in a skull of *Jacare sclerops* of same size. In outline the fenestræ are somewhat irregular; the interstral plate is relatively narrow. The anterior ends are broadly edged, and the posterior ends are slightly pointed.

INTERNAL NARIAL APERTURE.—This cavity is triangular in outline with the base of the triangle at the anterior end. The lateral borders, which converge backward, are elevated into distinct ridges, which extend back over the posterior surface of the skull. The aperture is divided by a median vertical septum into right and left portions.

The Bones of the Skull

PREMAXILLARIES.—The premaxillary bones are relatively long and narrow, and are irregular in outline. On the superior surface of the bone the premaxillo-maxillary suture on each side extends obliquely upward and backward from the inferior border to a point a little anterior to the level of the second maxillary tooth, then extends directly backward and joins the premaxillo-nasal suture at the level of the center of the space between the second and third maxillary teeth. The two premaxillaries are rather widely separated by the nasals, posterior to the narial aperture. The premaxillo-nasal sutures diverge slightly in the posterior direction.

On the palatal surface of the skull the premaxillo-maxillary suture is nearly transverse, but it sags slightly backward in a gentle curve, which crosses the level of the first maxillary teeth.

There are but four teeth in each premaxillary. The first of these is small, and is situated close to the median line. The first tooth, on each side, is separated from the second by a considerable space; the length of this space is equal to the height of the second tooth. The space is largely occupied by the deep pit which receives the large first mandibular tooth; this pit is almost directly in line with the premaxillary teeth, and not parallel to them. The second premaxillary tooth is considerably larger than the first; it is rather widely spaced from the third, but is not as far from the third as from the first. The small pit which receives the second mandibular tooth is situated in the space between the second and third maxillary teeth. The third tooth is the largest in the premaxillary; it is homologous with the fourth premaxillary tooth of those species which have five teeth in each premaxillary bone. The third is separated

by a considerable space from the small fourth premaxillary tooth; this space is occupied by a pit which receives the third mandibular tooth. The fourth premaxillary tooth, on each side, is about equal to the first in size. Internal to the deep pits along the premaxillo-maxillary suture, which lodge the fourth mandibular teeth, is a pair of small, but very distinct and deep foramina. In the fact that the pits in the premaxillaries which receive the mandibular teeth are practically in line with the teeth themselves, this species differs considerably from the various species of *Jacare*, *Crocodylus*, and *Alligator*.

MAXILLARIES.—Each maxillary bone exhibits a greater height than breadth. In this *Caiman trigonatus* differs from all other species except perhaps *C. palpebrosus*. The prominent ridge in front of each orbit is carried largely on the maxillary bone. The sutural connection with the premaxillary has been described in the discussion of that bone. The maxillo-nasal sutures are practically straight; they extend back from the posterior ends of the premaxillo-nasal sutures, and diverge slightly as far as the junctions of the maxillary, nasal, and lacrymal bones. The suture of each maxillary with the lacrymal on the same side of the skull extends downward and forward a very short distance from its origin at the posterior end of the maxillo-nasal suture, then turns abruptly downward and backward to the point where it is joined by the lacrymo-jugal suture; from this point the maxillo-jugal suture extends downward to a point very near the inferior border of the skull, over the thirteenth maxillary tooth, then extends almost directly backward and joins the inferior border a short distance posterior to the last maxillary tooth.

On the palatal surface of the skull the maxillaries occupy a considerable area. The maxillo-palatine suture is very irregular; it differs decidedly from the same suture in the species of *Jacare*. From a point very near the anterior end of the palatine fenestra, opposite the posterior border of the ninth maxillary tooth, each maxillo-palatine suture extends backward and inward to a point opposite the eleventh maxillary tooth, then turns forward and extends directly, but irregularly, to the level of the anterior edges of the eighth maxillary teeth, then turns at a right angle and extends directly, but irregularly in the transverse direction to the median line, meeting the similar suture from the opposite side. The suture of each maxillary with the corresponding ectopterygoid extends from the space between the twelfth and thirteenth maxillary teeth to the level of the palato-ptyergoid suture.

Each maxillary in the specimen studied contains fourteen teeth and an alveolar space for one more. Boulenger states that there ar

nineteen or twenty superior teeth in this species, consequently some individuals must have sixteen in each maxillary. The maxillary teeth increase in size from the first to the fourth; the fourth maxillary teeth are the largest of the superior series. Posterior to the fourth the maxillary teeth are all small. The anterior maxillary teeth are long and slender, and the posterior ones are short-crowned; none of the teeth are blunt, however. The anterior six or seven teeth in each maxillary are spaced rather widely, and not far from equally apart. Posterior to the eighth they are close together. Between the fifth and sixth and the sixth and seventh, but somewhat internal to them, are pits which receive mandibular teeth; they are not deep. Along the inner margins of the bony supports of the first four maxillary teeth are faint suggestions of pits to receive mandibular teeth.

NASALS.—The nasals are broad in proportion to the total breadth of the snout. At their maximum breadth, which is at the junctions of nasals, lacrymals, and jugals, the nasals occupy about half the total breadth of the snout. The nasals widen rapidly from their anterior projections into the narial aperture as far back as the posterior ends of the premaxillaries. Posterior to the contacts with the premaxillaries the nasals broaden gradually as far back as the junctions of the nasals with the lacrymals; this is at the level of the ninth maxillary teeth. Posterior to the level of the ninth maxillary teeth the nasals decrease in breadth to their posterior terminations, which are situated a considerable distance posterior to the anterior ends of the orbits. In this character *Caiman trigonatus* differs from most, if not all other Recent crocodilians. The posterior ends of the nasals are not in contact with each other, but are widely separated by the broad anterior process of the frontal. The posterior portions of the nasals in fact consist of two backward projecting processes, which wedge between the frontal on the one hand, and the prefrontals on the other. The contact of each nasal with the lacrymal is considerably shorter than its contact with the prefrontal. Along the median line, in the specimen studied, is a narrow sliver of bone between the two nasals. This is not regarded as possessing any particular significance, merely being the result of accessory ossification.

LACRYMALS.—The lacrymal bones are relatively large, and are nearly vertical in position. Their contacts with the nasals and maxillaries have been described above. The sutures with the prefrontals are obscure in the specimen examined. Each of them extends from the posterior end of the naso-lacrymal suture directly backward to a point near the anterior border of the orbit. It then turns almost directly outward toward the

antero-internal border of the orbit. The suture with the jugal extends directly back from the lower extremity of the maxillo-lacrymal suture to the antero-inferior border of the orbit. The lacrymals carry the knob-like processes anterior to the orbits, also a pair of ridges, which extend downward and forward from the anterior ends of the orbits to the inferior extremities of the maxillo-lacrymal sutures; they are perpendicular to the latter sutures in position.

PREFRONTALS.—The prefrontal bones are small and irregular. Each prefrontal has no separate anterior border, but an irregularly curved internal border. This internal border is composed partly of the suture with the nasal, and partly of that with the frontal. Each suture with the frontal is unusually short, in correlation with the great length of the corresponding posterior process of the nasal. On the external border of each prefrontal, about midway between the anterior and posterior ends of the bone, a short process projects outward; the anterior boundary of this process is part of the lacrymo-prefrontal suture, and the external and posterior boundaries are the orbit itself.

FRONTAL.—The frontal is relatively large, especially in its anterior portion. The anterior process is both long and broad. It wedges apart the two posterior processes of the nasals; the contact with the nasals consists of an irregular transverse suture, and two straight almost antero-posterior sutures. Each of these straight sutures is continued backward as the prefronto-frontal suture to the center of the superior border of the orbit. Each naso-frontal suture is considerably longer than the prefronto-frontal suture. The interorbital plate is moderately broad, and is not concave. The posterior boundary of the frontal is a suture which extends inward and backward from the posterior border of the orbit at an angle of about 45° with the longitudinal axis of the skull, then directly across in a transverse direction, and on the opposite side, forward and outward to the orbital border. The transverse portion of this suture is somewhat longer than either of the oblique portions. The contact with the parietal occupies the transverse portion of the suture, and about two-fifths of each oblique portion, the remaining three-fifths being occupied by the fronto-postorbital contacts.

POSTORBITALS.—The postorbitals are of moderate size; they are flat on their external surfaces, and are irregularly quadrangular in outline. The fronto-postorbital sutures have been described above. The post-orbito-parietal sutures extend backward and slightly outward from the contacts with the frontal. The postorbito-squamosal sutures are directly transverse in direction, and are approximately equal in length to the postorbito-parietal sutures.

SQUAMOSALS.—The squamosal bones are large and flat. In outline they are five-sided, but are almost rectangular. The external border is the longest; the posterior border, which is perpendicular to the external one, is next in size; the internal border, which is parallel to the external one, is slightly shorter than the posterior; the transverse anterior, and oblique antero-internal borders are small and equal in size.

PARIETAL.—The parietal bone is large in size, occupying the central portion of the flat cranial table; the large size is correlated with the absence of supratemporal fenestræ. The lateral borders are slightly irregular. The anterior border has been described above as the posterior border of the frontal. The bone occupies two short portions of the posterior border of the cranial table, these portions being separated by the supraoccipital. The latter bone is long, separating two rather long slender processes of the parietal from each other.

SUPRAOCCIPITAL.—On the surface of the cranial table this bone is long antero-posteriorly, and narrow laterally. It occupies the median portion of the posterior border of the cranial table. On the posterior surface of the skull the supraoccipital occupies somewhat more than one-third of the total breadth, and extends down from the superior border about three-fifths of the total distance from this border to the foramen magnum.

EXOCCIPITALS.—The exoccipital bones are characterized by a somewhat greater vertical height than those of most Recent crocodilians.

BASIOCCIPITAL, BASISPHENOID, AND QUADRATES.—These bones are not sufficiently characteristic to require special description.

QUADRATO-JUGALS.—The quadrato-jugals are very broad in their posterior portions, but very slender in their anterior portions. They have no suggestions of free anterior processes.

JUGALS.—The broad anterior portions of the jugals are nearly vertical in position, otherwise are not especially characteristic.

PALATINES.—The form of the palatine bones is characteristic. The maxillo-palatine sutures have been described above. The anterior processes of the palatines are nearly rectangular in outline. The inter-fenestral portions are slightly narrower than the anterior processes opposite the twelfth maxillary teeth; posterior to this level they expand slightly. The palato-pterygoid suture is situated a considerable distance anterior to the posterior ends of the palatine fenestræ. It extends across the interorbital plate in a series of loops. The forward position of this suture may be due partly to the young age of the specimen studied, and may not have specific value.

PTERYGOIDS.—These bones occupy considerable portions of the postero-internal borders of the palatine fenestræ. They are flat along the median line, and bend downward at the borders only slightly. They are somewhat elevated around the internal narial aperture. Posterior to the aperture a pair of short processes extend backward from the posterior border.

ECTOPTERYGOIDS.—The anterior processes of these bones are very small, extending only as far forward as the level of the fourteenth maxillary teeth. The postero-superior processes are also small; the inferior processes are large.

The Mandible

The mandible of this species is slender. The symphysis is short, extending back only to the level of the fourth mandibular teeth. The splenial bones extend about as far forward as the fifth mandibular teeth. The articular surfaces of the articular bones are not divided by transverse ridges as in some of the species of *Jacare*. The anterior end of the two rami forms a sharp point. The external mandibular foramina are large.

The right ramus contains twenty-two teeth and the left twenty-one. Boulenger states that there are from twenty to twenty-two mandibular teeth on each side. From the first to the fifth the mandibular teeth are far apart, especially the second and third. From the fifth teeth back to the posterior end of the dental series the teeth are only moderately, and nearly equally far apart. The first and the fourth mandibular teeth are approximately equal in length, but the fourth are stouter than the first. The second and third are of medium size, also the twelfth and thirteenth. The fifth to the eleventh teeth and those posterior to the thirteenth, are small. The crowns of the anterior teeth are considerably longer than those of the posterior ones, but the latter are not especially blunt.

Measurements Mus. Univ. Mich. No. 46113

Length of Skull, Tip of Snout to Supraoccipital	.1595M.
Length of Skull, Tip of Snout to Ends of Quadrates	.1660
Breadth of Skull Across Quadrato-jugals	.084
Breadth of Cranial Table	.049
Breadth of Snout at Base	.057
Breadth of Snout at Fourth Maxillary Teeth	.044
Breadth of Snout at Third Premaxillary Teeth	.029
Length of Mandible	.184
Breadth of Mandible, Maximum	.084

Calman palpebrosus (Cuvier)

No skull of this species was available for study. The following description is from Boulenger. "19 or 20 upper and 20 lower teeth on each side; third and fourth maxillary teeth largest. Head once and three-fifths to once and two-thirds as long as broad; snout subacuminate, its basal width contained about once and a half in its length; no cross-ridge in front of the interorbital region, which is but slightly concave; upper eyelid flat and smooth, entirely bony, the bony plate consisting of four distinct pieces; lores very steep and high; canthus rostralis angular; supratemporal fossæ obliterated."

ALLIGATOR Cuvier

GENERIC CHARACTERS

In *Alligator* the snout is short and rounded anteriorly. The supratemporal fenestræ are small; the external narial aperture is divided medially by a pair of long anterior processes of the nasal bones and a corresponding pair of short processes from the premaxillary bones. There are seventeen to twenty upper teeth on each side, and eighteen to twenty lower teeth. There is no sharp anterior process to each quadratojugal. The fourth mandibular teeth bite into pits in the upper jaws; the mandibular teeth in general bite inside the line of the superior teeth. In one character *Alligator mississippiensis* differs from all the other crocodilians studied; it is not known at present whether it is true of *A. sinensis* or not; if not that form is not closely allied with *A. mississippiensis*. This character, which was called to the writer's attention by Prof. W. K. Gregory, is related to the contact of the lacrymals with the surrounding bones. In all the other crocodilians studied the lacrymals form contacts with the nasals. In this species the lacrymals are separated from the nasals by the greatly elongated anterior processes of the prefrontals. The lacrymals therefore come in contact with the jugals, maxillaries, and prefrontals only. The maxillaries, in consequence of this separation of the lacrymals and jugals, are in contact with the prefrontals.

Alligator mississippiensis Daudin

The description of the skull of *Alligator mississippiensis* is based upon a series of skulls of greatly varying ages. They are, in order of increasing size, the following specimens: two very small skulls in the collections of the Museum of Comparative Zoology (Nos. 13101 and 13102), neither of which is over 40 mm. long; Amer. Mus. Nos. 2321 and 2320;

another skull in the collections of the Museum of Comparative Zoology (No. 13103), about 100 mm. long; Amer. Mus. No. 12572, about 200 mm. long; Amer. Mus. No. 15180 about 340 mm. long; another skull of practically the same size (Amer. Mus. No. 15178); and Amer. Mus. No. 15181, about 490 mm. long.

General Form

The skull of the American alligator is broad and flat; the region of the snout is especially so. The snout varies from about equal length and breadth at the base in the very young skulls to a length about one and two-thirds as long as the breadth at the base in the oldest skull. The lateral margins of the snout are unusually smooth; in the very young individuals they converge rather sharply in the anterior direction, the anterior end of the snout being rather acute; in the older specimens the margins of the snout are almost parallel, and the end of the snout is very broadly rounded. The fourth mandibular teeth bite into pits in the upper jaw, instead of into grooves as in *Crocodylus*, consequently there is no sharp constriction of the snout at the premaxillo-maxillary suture; the snout is very slightly expanded at the level of the fourth maxillary teeth, and very slightly constricted a short distance posterior to that level. These slight constrictions and expansions are very much less marked than in *Crocodylus*, and are in different positions. There is an elevation above each fourth maxillary tooth, and in Amer. Mus. No. 15180 the left of these has been pierced by the root of the tooth (evidently after the preparation of the skull) showing the extremely thin character of the bone. The snout varies greatly in its degree of pitting; the older skulls are of course much more deeply pitted than the younger ones. In some skulls the median posterior portion of the snout is relatively smooth, while the borders of the snout are deeply pitted, and there is a sharp transition from the smooth to the rough areas. In other skulls the degree of pitting is more nearly equal; in still others the posterior median area of the snout is smooth, but grades into the rougher borders. The meaning of this type of variation is not known, but it may possibly be geographic in nature. The external narial aperture is divided into two portions by a median septum.

The interorbital region is relatively narrow, and is strongly uprolled. The cranial table is of moderate size; it varies considerably in outline. In the younger specimens there is a tendency toward convexity in the external borders of the table; in the older skulls the lateral borders converge slightly in the anterior direction. This is not invariably the case,

asin in the largest skull studied (Amer. Mus. No. 15181) the borders converge less than in two smaller skulls. The height of the skull, especially in the region of the snout, but also in the cranial region, is not great.

The Cavities of the Skull

SUPRATEMPORAL FENESTRÆ.—In the older specimens these fenestræ are of moderate size, and are close together. They are very irregular in outline, and their greatest diameters converge anteriorly. In the young skulls they exhibit the characteristic juvenile crocodilian features of great length in proportion to their breadth, and wide separation from each other. In the older skulls they are very much smaller than the lateral halves of the external narial aperture.

INFRATEMPORAL FENESTRÆ.—The infratemporal fenestræ are moderately large, and are subtriangular in outline. The postorbital bars which form their anterior boundaries slope more obliquely downward than in the true crocodiles. The fenestræ are not penetrated by sharp processes of the quadrato-jugals, as in the species of *Crocodilus* and *Tomistoma*.

ORBITS.—In the young skulls the orbits are excessively large; in the older ones they are relatively small, with intermediate conditions in the intervening stages. The orbits of the older skulls are considerably longer than they are broad; this is true to a slight extent in the young skulls. In the older specimens the orbits are rather sharply pointed at their anterior ends; their internal borders are very deeply concave, and these borders, especially at their anterior ends, are conspicuously elevated; the inferior, or external borders are slightly concave inward in the younger stages, but in the older ones they are more nearly straight, and in the oldest of all (Amer. Mus. No. 15181) they are very slightly convex inward. This makes the outline of each orbit exceedingly irregular.

EXTERNAL NARIAL APERTURE.—The external narial aperture is large. Its anterior breadth is greater than its posterior. Its total breadth is considerably greater than its length. It is completely divided into right and left portions at the surface of the snout by the enlarged anterior processes of the nasal bones, and shorter processes of the premaxillaries which extend backward to meet the nasal processes. There is no bony separation of the aperture at a lower level, however.

PREMAXILLARY FORAMEN.—This cavity is comparatively large. It is rounded at its posterior end and sharply pointed at its anterior end; its lateral boundaries are curves which are deeply concave in their posterior halves, and gently convex in their anterior halves.

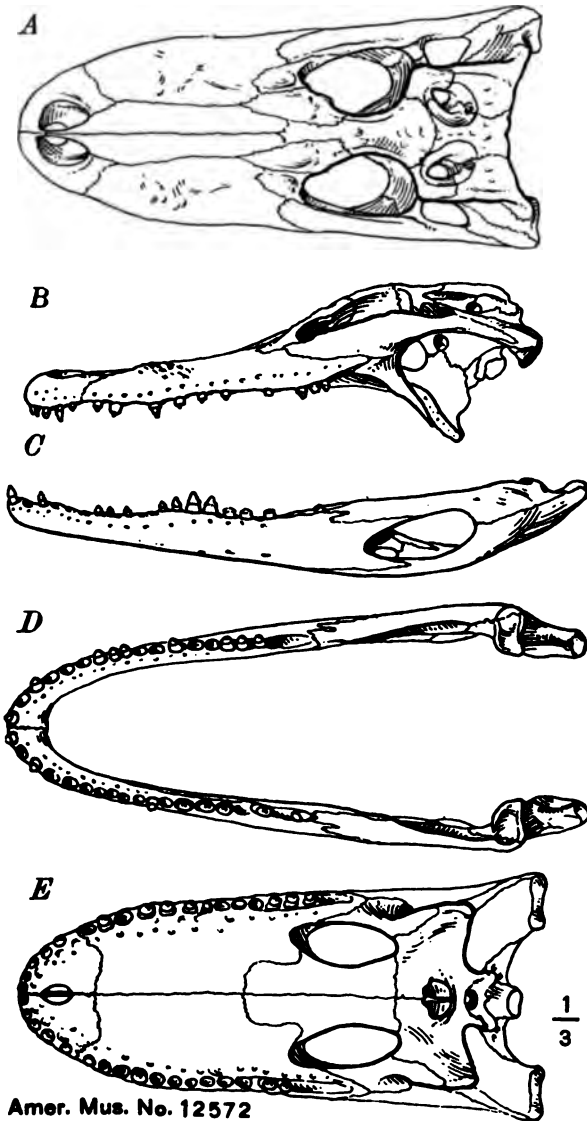
PALATINE FENESTRÆ.—The palatine fenestræ are rather small and far apart, especially in the older specimens. In the younger skulls they are relatively somewhat larger, especially in the transverse direction. In the youngest specimen they are about twice as long as broad. In all of the young specimens they are relatively close together. In all of the skulls up to and including the 10 cm. skull of the Museum of Comparative Zoology Collection, the space between the two fenestræ is not greater than the breadth of either fenestra. In the oldest specimen (Amer. Mus. No. 15178) the minimum transverse diameter of the interfenestral plate is nearly twice as great as the maximum transverse diameter of each of the fenestræ. The younger individuals have rather symmetrically shaped fenestræ; the older ones have them very irregular in outline. In all of the older skulls the fenestræ are long and narrow, and their anterior ends are rounded. Their external borders are irregularly concave; their internal borders are nearly straight lines which converge sharply in the posterior direction, but near their posterior ends they curve inward around an expansion of the nasal passage, and in the oldest specimen curve outward, and finally inward again. The posterior ends of the fenestræ are sharp; their greatest transverse diameters are near their posterior ends. In the youngest skulls they extend forward to the level of the tenth maxillary teeth; in the older ones they extend as far forward as the anterior borders of the eleventh.

INTERNAL NARIAL APERTURE.—This cavity faces downward and slightly forward. It is large, occupying about half the median length of the pterygoids. It is completely divided by a median bony septum, and it extends far up into the basicranial region of the skull; its median septum is supported laterally, inside the cavity, by a series of lateral bars, or braces. Externally it is shielded posteriorly by a ridge of the pterygoids.

The Bones of the Skull

PREMAXILLARIES.—The premaxillaries are very broad and short. Their very small posterior processes extend only as far back as the level of the second maxillary teeth; the narial aperture extends back to the level of the first maxillary teeth, so the post-narial portion of each premaxillary is very small. From the anterior border of the aperture a pair of closely appressed processes of the premaxillaries extend backward to meet the long anterior processes of the nasals.

On the palate the premaxillo-maxillary suture is rather irregular in outline. From the lateral border it extends inward and backward a short distance to a point slightly posterior to the level of the first maxil-



Amer. Mus. No. 12572

Fig. 14. Skull and jaws of *Alligator mississippiensis* Daudin. Amer. Mus. No. 12572, one-third natural size. A, superior view of skull; B, lateral view of skull, left side; C, lateral view of mandible, left side; D, superior view of mandible; E, inferior view of skull.

lary teeth, and anterior to the second, or in line with their anterior borders, and about one-third the distance inward from the margin of the jaw to the median line. Then it turns inward and very slightly forward, meeting its opposite on the median line opposite the first maxillary teeth. The maximum length of the premaxillaries on their palatal surface is about three-fifths their total breadth; on the superior surface the length is about four-fifths the breadth.

There are normally five teeth in each premaxillary; in one specimen, however, one of the first pair was not developed. The teeth increase regularly in size from the first to the fourth; the fifth is approximately equal in size to the third. The teeth are all spaced moderate distances from each other. The pits which lodged the mandibular teeth are all situated internal to the line of the premaxillary teeth, the lower teeth biting entirely within the upper ones. The first of these pits, on each side, internal to the second tooth and the space between the first and second, is deep, but does not pierce the surface of the skull. The second pit, opposite the space between the third and fourth teeth, is small; the third pit, internal to the space between the fourth and fifth teeth, is also small. The pit which lodges the fourth mandibular tooth is deep; it is internal to the line of both premaxillary and maxillary teeth, and is situated on the suture between the two bones; its deepest point lies in the premaxillary and not the maxillary.

MAXILLARIES.—The maxillary bones are very short in the younger skulls, but are relatively longer in the older ones. In all of the skulls they are relatively broad in proportion to their length. Their sutures with the nasals are convex (in the direction of the maxillaries) in the young individuals, and straight or slightly concave in the older ones. Their sutures with the prefrontals, lacrymals, and jugals are very irregular, together forming a series of loops across the posterior portion of the snout. In having contacts with the prefrontals the maxillaries of the alligator differ from those of all other crocodilians, in which the maxillaries are excluded from contact with the prefrontals by the lacrymals, which usually form contacts with the nasals.

On the palate the maxillaries occupy a considerable area. Their suture with the premaxillaries has been described above. The maxillo-palatine suture differs somewhat from that of most crocodilians. It extends backward and inward from the anterior end of the palatine fenestra, on each side, for a short distance only, then turns and extends almost directly forward to the level of the ninth maxillary teeth in the

olderspecimens, and the eighth in most of the younger ones, then extends almost directly inward to the median line, and in a symmetrical direction to the opposite border. In the two youngest specimens the suture differs somewhat from this outline. In the very smallest one the suture extends almost directly forward and inward from the anterior end of the fenestra, to meet its opposite on the median line opposite the seventh maxillary teeth, the two lateral portions together forming a letter V, with the apex directed forward. In the second smallest skull the suture extends obliquely inward and forward to a point opposite the seventh maxillary teeth, as in the one just described, but then turns directly inward and meets its opposite on the median line at that level. The maxillaries are excluded from the internal borders of the fenestræ, and form only small portions of their external walls. The maxillo-ectopterygoid sutures extend forward to the level of the twelfth or the thirteenth maxillary teeth, varying somewhat among the skulls studied. The maxillaries do not extend far back of their alveolar borders.

There are fifteen teeth in each maxillary. These are directly in line with the premaxillary teeth. They increase regularly in size from the first to the fourth, which is the largest in each maxillary. From the fifth to the seventh, inclusive, the maxillary teeth decrease in size. From the eighth to the eleventh, inclusive, they increase; the eleventh is second in size to the fourth. From the twelfth to the fifteenth, inclusive, they decrease regularly.

The maxillary teeth, from the first to the sixth, are close together, likewise the eighth and ninth; the sixth and seventh, and the seventh and eighth are considerably farther apart than the others; from the tenth to the fifteenth they are very close together, in fact from the eleventh to the fifteenth their alveoli are continuous with each other. The crowns of the anterior maxillary teeth are moderately long, like those of the premaxillary teeth, but they do not have the relatively great length of those of most typical crocodiles; the crowns of the posterior maxillary teeth are very short. All of the teeth are rather short and stout. The anterior teeth are more or less pointed, but not sharply so; the posterior teeth are very blunt. Conspicuous pits for reception of the mandibular teeth are situated internal to the spaces between the sixth and seventh, and the seventh and eighth teeth in each maxillary. Anterior to this level there are very slight indentations of the maxillaries which lodge mandibular teeth; all of them are entirely internal to the line of teeth themselves. The transition from sharp to blunt teeth is more gradual than in most true crocodiles.

NASALS.—The nasal bones are broad in comparison with those of other crocodilians, but not in proportion to the breadth of the snout. Their anterior processes extend forward into the nasal aperture, and joining with a pair of short processes of the premaxillaries, completely divide the aperture into right and left portions at the surface. At the posterior ends of the two lateral halves of the aperture they are broad, and occupy considerable portions of the postnasal borders. Their breadth at the posterior end of the aperture is much greater than in any other crocodilian skull studied. Posterior to the aperture they expand rapidly to the level of the fourth maxillary teeth, where they reach their maximum breadth. Posterior to the level of the fourth maxillary teeth they vary somewhat in the various individuals; in some their external borders remain almost parallel; in others they converge slightly in the posterior direction, and then diverge again; the positions of the minimum breadth of the anterior portions of the nasals, and of the expansion back of this, vary considerably. In all the specimens examined the nasals decrease in breadth rapidly posterior to the anterior end of the naso-prefrontal sutures. The nasals have no contacts with the lacrymals. The posterior ends of the nasals, between, or in some cases slightly anterior to the anterior ends of the orbits, are irregular; in some specimens the two nasals are very slightly wedged apart by a minute extension of the anterior process of the frontal; in others they are irregularly transverse.

LACRYMALS.—The lacrymal bones of the alligator are unusual. They have no contacts with the nasals; they are much shorter than the prefrontals, and do not extend as far forward or as far backward as these bones; they are slightly broader than the prefrontals; their longitudinal axes are nearly parallel with the longitudinal axis of the skull.

PREFRONTALS.—The prefrontals are unusually long. Their external and internal borders converge anteriorly, forming sharp points at the anterior ends of the bones; their contacts with the maxillaries are about one-half as long as their contacts with the nasals. Their posterior ends, along the borders of the orbits, are very rugose.

FRONTAL.—The anterior process of the frontal is comparatively short, being considerably shorter than the posterior plate; it is of moderate breadth. The interorbital plate is relatively narrow, and its edges are sharply uprolled. The posterior expansion, posterior to the orbits, is slight.

POSTORBITALS.—These bones are of medium size. Each occupies about one-third of the lateral border of the cranial table, and its orbital border is slightly shorter than its lateral border. Each forms a part of

the antero-internal as well as the external border of the supratemporal fenestra.

SQUAMOSALS.—The squamosals are moderately large. Together they occupy about five-sevenths of the posterior border of the cranial table. Their sutures with the parietal are concave, but tend to converge in the anterior direction.

PARIETAL.—In most of the specimens the parietal occupies much of the entire posterior border of the cranial table. In the very young specimens the supraoccipital wedges in as a process on the median line. In the oldest one there is a very minute process of the supraoccipital visible on the cranial table, preventing the parietal from occupying the entire central portion of the posterior border.

SUPRAOCCIPITAL.—As noted above the supraoccipital has little or no representation on the surface of the cranial table. The smaller skulls, including the 10 cm. skull of the Museum of Comparative Zoology Collection, exhibit an appreciable surface of this bone on the cranial table. The three skulls which are somewhat larger (Amer. Mus. Nos. 12542, 15180, and 15178) show no traces of it whatever. The largest skull (Amer. Mus. No. 15181) exhibits the bone as a minute area on the posterior border, as mentioned above.

The smallest skull in the collection studied (Mus. Comp. Zool. No. 13101) possesses not only a supraoccipital but a dermo-supraoccipital, which is separated from the true supraoccipital and from the parietal by sutures. In the next to the smallest skull (Mus. Comp. Zool. No. 13102) this dermo-supraoccipital is distinguishable, but it appears to be almost united with the parietal.

On the posterior surface of the skull the supraoccipital extends downward from the superior border to a point about two-thirds the distance from this border to the foramen magnum. Its breadth is about two-fifths as great as the breadth of the posterior border of the cranial table.

EXOCCIPITALS, BASIOCCIPITAL, BASISPHENOID, AND QUADRATES.—These bones are not especially characteristic, and need no special description.

QUADRATO-JUGALS.—These bones differ considerably from those of the true crocodiles. Their superior, or quadrate, borders are irregularly curved; they lack altogether the sharp processes extending into the infratemporal fenestræ, which are conspicuous in the species of *Crocodilus* and *Tomistoma*. The antero-superior processes are large, both in length and thickness; they extend upward and forward, and articulate with the postorbitals as well as the squamosals and quadrates.

JUGALS.—The jugal bones are relatively short and broad. Their posterior processes are thin, but their entire anterior halves are deep vertically; in their anterior regions they differ in this character from the jugals of the true crocodiles, in which the anterior halves are considerably lower, or narrower, than the central portions.

PALATINES.—The palatine bones are very distinctive in outline. Their sutures with the maxillaries have been described above. They extend forward to the level of the eighth, ninth, or tenth maxillary teeth. Their anterior processes are considerably broader than they are long, and they are terminated by nearly straight transverse borders. The palatines form all of the internal borders of the palatine fenestræ in some skulls, and all except exceedingly short distances near the posterior ends in others. They form about one-fourth of the external borders of these fenestræ.

The sutures of the palatines with the pterygoids are distinctive in outline. They vary considerably among themselves, but their paths may be described as follows: each palato-ptyergoid suture extends backward and inward from a point at or near the posterior end of the palatine fenestra, for a short distance, then turns inward and slightly forward for an equal distance, then turns inward and backward again, and meets its opposite on the median line. The variation concerns the obliquity of the external portion, the degree of irregularity, the level of the juncture with the median line, and other characters of the same general description.

The palatines are relatively short in proportion to their breadth. Their minimum diameter is transverse in direction, at the level of the juncture of the maxillary, jugal, and ectopterygoid bones. Posterior to this point they broaden slightly, and anterior to it they broaden considerably, making the anterior ends of the palatine fenestræ very narrow. The anterior processes, which are much narrower than the maximum breadth of the bones, are considerably broader than the posterior ends of the bones. At the ends of the anterior processes the palatines occupy at least one-third of the total breadth of the palatal surface.

PTERYGOIDS.—The pterygoids are very short antero-posteriorly. The large internal narial aperture occupies about one-half of their length along the median line. They occupy small portions of the posterior, or postero-external, surfaces of the palatine fenestræ, the actual extent varying considerably among the different specimens. They appear to be fused together at their posterior ends; posterior to the internal narial aperture they are elevated into a curved ridge, which protects the aperture on its posterior border; they also send forward a median partition in the aperture and farther up in the nasal passage.

ECTOPTYERYGOIDS.—The bones are somewhat characteristic. Their anterior processes extend forward to the twelfth or the thirteenth maxillary teeth; these anterior processes are sharply pointed. Their superior processes are large, and their postero-inferior processes are relatively slender.

The Mandible

The mandible is relatively broad, especially near its anterior end. This is true in spite of the fact that its teeth bite entirely inside the premaxillary and maxillary teeth. The symphysis is short, extending as far back as the fourth mandibular teeth in some specimens, and in others not behind the third. The splenials extend to the posterior ends of the fourth mandibular teeth.

There are nineteen or twenty teeth in each ramus. These resemble the teeth of the upper jaws in general form, although some of them are more sharply pointed. The fourth tooth is the longest in each ramus, but the twelfth is considerably thicker. The teeth between the fourth and the twelfth (or thirteenth) are small; those posterior to the twelfth (or thirteenth) are somewhat larger, but decrease progressively from the thirteenth to the twentieth. The first twelve (or thirteen) teeth are relatively sharp-pointed, but from that point back to the end of the series the teeth are all blunt.

There is a great variation in the spacing of the mandibular teeth; the third and fourth (Amer. Mus. No. 15178, in which there are nineteen mandibular teeth on each side), the seventh and eighth, and the tenth and eleventh teeth are close together, also all the teeth posterior to the twelfth; the first and second, the second and third, the fourth and fifth, the fifth and sixth, the sixth and seventh, and the ninth and tenth are moderately far apart; the eighth and ninth are very far apart. The extra tooth in the jaws which have twenty appears to be in the region immediately posterior to the large fourth tooth; the jaw with nineteen therefore has seven small teeth between the fourth and the next large tooth, while the jaws with twenty have eight.

Remarks

This species appears to be very widely separated in the structure of the skull from all of the other species studied. From the descriptions the small Chinese relative (*Alligator sinensis*) may partially bridge over the gap between the species described and the true crocodiles, but this is uncertain. The American alligator appears to be as distantly related to

Measurements

	Mus. Comp. Zool.		Amer. Mus.		Mus. Comp. Zool.	Amer. Mus.		
	No. 13101	No. 13102	No. 2321	No. 2320	No. 13103	No. 12572	No. 15178	No. 15180 No. 15181
Length of Skull, Tip of Snout to Supraoccipital	.036M.	.039M.	.052M.	.057M.	.096M.	.197M.	.335M.	.325M. .490M.
Length of Skull, Tip of Snout to Extremities of Quadrates	.035	.039	.053	.058	.098	.210	.370	.368 .549
Length of Snout	.014	.016	.025	.027	.049	.116	.217	.215 .337
Breadth of Skull Across Quadrato-jugals	.019	.021	.027	.030	.046	.098	.182(est.)	.182 .252
Breadth of Snout, Base	.015	.017	.024	.028	.042	.083	.148	.148 .215
Breadth of Snout Across Fourth Maxillary Teeth	.....	.....	.....	.....	.088	.073	.132	.134 .203
Length of Mandible	.036	.....	.056	.063	.....	.237	.407	.....
Breadth of Mandible	.018	.....	.....	.035	.....	.099	.192	.....

the caimans as to the true crocodiles. The similarities with the skulls of the various species of caimans appear to be superficial in character, and not necessarily indicative of close relationship. The American alligator, and presumably its Chinese relative as well, has evidently descended from a different Mesozoic ancestor from the remainder of the Crocodilia.

Alligator sinensis Fauvel

No skull of this species was available for study. The following description is quoted from Boulenger. "17 or 18 upper and 18 or 19 lower teeth on each side. Head nearly once and a half as long as broad; dorsal outlines of snout converging towards the end, which is obtusely rounded; upper eyelid entirely bony."

SPECIES NOT RECOGNIZED AS VALID

No attempt has been made, in the present study, to verify or correct the synonymy of the Recent crocodilian species as given by Boulenger. However, several species which are recognized by Boulenger are not recognized as valid in the present study, . . .

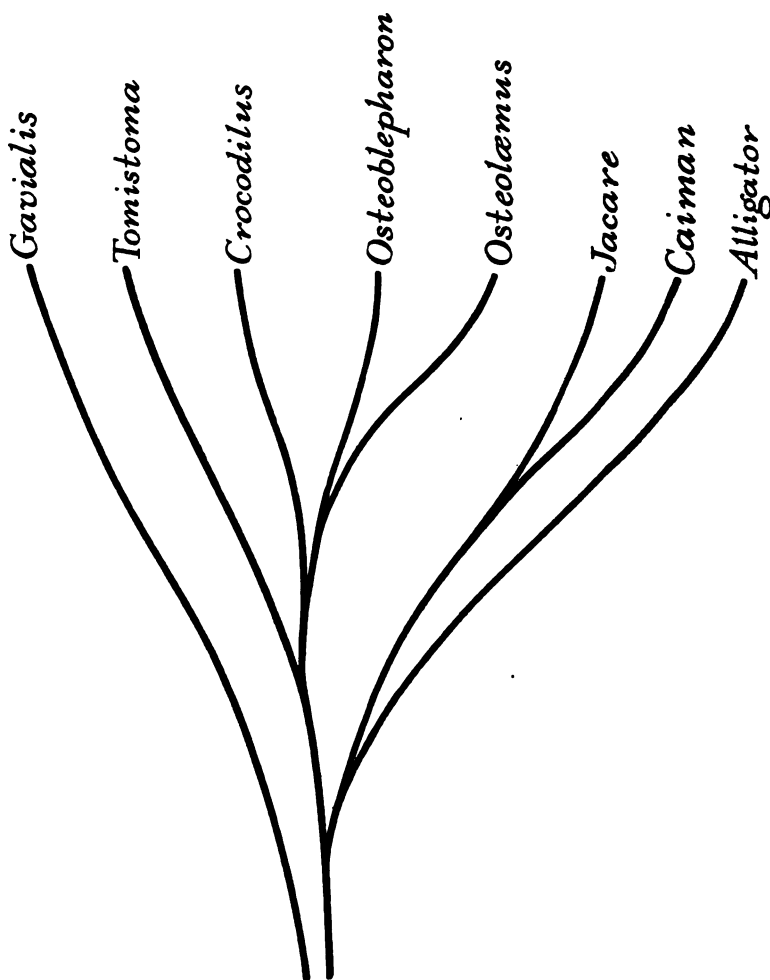
Barbour has discussed the synonymy of *Crocodylus rhombifer* Cuvier, and *C. moreletii* Duméril, and given reasons why the latter species should be considered synonymous with the former. The same writer has discussed *C. robustus* Vaillant and Grandidier, and has found that it is listed as a fossil species, but not as a Recent one. Barbour also considers *Alligator helois* Cope, to be based upon insufficient grounds. Fowler has discussed *Perosuchus fuscus* Cope, and considered it, upon good grounds, to be a synonym of *Caiman (Jacare) sclerops*.

DISCUSSION OF THE AFFINITIES OF THE VARIOUS GENERA OF RECENT CROCODILIA

From the characters described above it will be seen that *Gavialis* is more or less remote from a central crocodilian stem on the one hand, and *Alligator* is remote from this stem on the other. *Crocodylus* may be considered as intermediate between *Gavialis* and *Alligator*. *Tomistoma* is then intermediate between *Gavialis* and *Crocodylus*, but resembles the latter much more closely than the former. *Osteoblepharon* is evidently very closely related to *Crocodylus*, and in many respects is intermediate between this genus and *Osteolemus*. In certain superficial characters *Osteolemus* resembles *Alligator*; it is unlikely, however, that there is any close degree of relationship between these two genera. *Jacare*, *Caiman*,

and *Alligator* have a number of rather important characters in common. Of the three *Jacare* is the most primitive, and bears the greatest resemblance to *Crocodilus* and *Osteoblepharon*. In the character of its supra-occipital this genus differs from all other Recent genera of crocodilians, however. In most of its characters, especially those of importance *Alligator* is very remote from *Crocodilus*.

The relations of the genera of Recent crocodiles, as indicated from a study of Recent species only, are probably somewhat as indicated in the accompanying diagram. A study of the fossil species may necessitate a revision of this outline.



SYNOPSIS OF THE CRANIAL CHARACTERS OF THE GENERA OF RECENT CROCODILIA

This synopsis is based upon that of Boulenger, and differs but little from it. A few modifications have been introduced, however, chiefly in connection with the recognition of *Jacare* Gray and *Osteoblepharon* Schmidt as valid genera.

- I. Nasal bones widely separated from the nasal aperture; splenial elements entering the mandibular symphysis, which extends at least to the fifteenth tooth.
 - A. 27-29 superior, 25-26 inferior teeth on each side, none of the mandibular teeth received into pits; nasal bones widely separated from premaxillaries. *Gavialis*.
 - B. 20-21 superior, 18-19 inferior teeth on each side, the lateral mandibular received into pits between the maxillary teeth; nasal bones in contact with the premaxillaries. . . *Tomistoma*.
- II. Nasals entering the nasal aperture; splenial elements not entering the mandibular symphysis; the latter does not extend back of the eighth tooth.
 - A. Fourth mandibular tooth usually fitting into a notch in the jaw; 16-19 superior, and 14-15 inferior teeth on each side.
 - i. No bony nasal septum.
 1. Fronto-parietal suture does not enter supratemporal fenestræ, maxillo-palatine sutures extend considerably anterior to ends of palatine fenestræ. *Crocodilus*.
 2. Fronto-parietal suture enters supratemporal fenestræ; maxillo-palatine sutures do not extend far beyond the ends of the palatine fenestræ. *Osteoblepharon*.
 - ii. Nasal bones dividing the nasal aperture. . . . *Osteolæmus*.
 - B. Fourth mandibular tooth usually fitting into a pit in the upper jaw; 17-20 superior and 17-22 inferior teeth on each side.
 - i. No bony nasal septum.
 1. Supratemporal fenestræ not closed except in very old individuals; premaxillary foramen elongate; parietal bone forms no part of posterior border of cranial table; 5 premaxillary teeth, 17-20 mandibular teeth on each side. *Jacare*.

2. Supratemporal fenestræ closed; premaxillary foramen broad; parietal bone forms part of posterior border of cranial table; 4 premaxillary teeth; 20-22 mandibular teeth on each side. *Caiman*.
- ii. Bony septum divides external narial aperture. . . *Alligator*.

Article XIV.—OLIGOCHÆTA COLLECTED IN GREENLAND BY THE CROCKER LAND EXPEDITION¹

BY PAUL S. WELCH

The oligochæte collections of the Crocker Land Expedition, made by Dr. M. C. Tanquary, were sent to the writer for study and identification. In spite of the meagerness of the collections and the fact that they were all taken in one locality (Umanak, Greenland), the specimens are of considerable interest. Until recently (Smith and Welch, 1919) the whole arctic portion of North America was practically unknown territory so far as these animals were concerned. As pointed out in the above-mentioned publication, *Lumbriculus variegatus* (O. F. Müller), *Lumbricillus profugus* (Eisen), *Lumbricillus minutus* (O. F. Müller), and *Enchytræus albidus* Henle were reported from Greenland many years ago and constituted the only records for the great expanse of territory between that country and Bering Strait until the recent publication of the results of the Canadian Arctic Expedition, which gives some indication of the oligochæte fauna in arctic America. The Crocker Land Expedition material, in a general way, completes the survey of this group across the continent.

Two recognizable species, *Lumbriculus variegatus* (Müller) and *Mesenchytræus falciformis* Eisen, and another unidentified form, *Mesenchytræus* species, comprise the collections. *Lumbriculus variegatus* was common in the Canadian Arctic Expedition collections and now the old record of this form in Greenland, made by Eisen in 1872, has been definitely confirmed. Representatives of *Mesenchytræus* are reported in Greenland for the first time, although they were to be expected since the genus is known to have a wide distribution in the arctic portions of the whole northern hemisphere. Both of the recognizable species of these collections occur in arctic Eurasia. A list of the literature dealing with the North American species of *Mesenchytræus* will be found in a previous publication (1919) by the writer.

ENCHYTRÆIDÆ

Mesenchytræus falciformis Eisen

One of the collections, made at Umanak, Greenland, June 22, 1914, contained twenty-three specimens, eleven of which are sexually mature. The remaining twelve specimens exhibit varying degrees of immaturity

¹Contribution from the Zoological Laboratory of the University of Michigan.

and were of little assistance in the determination of the species. The only other information accompanying the collection is that they were found "in fresh water stream."

A study of these enchytræids based upon serial sections and cleared whole mounts showed a very close agreement with the descriptions of *Mesenchytræus falciformis* Eisen. While the latter has not been as completely described as is desirable, yet enough is known about Eisen's original material to make it safe in identifying this Greenland form as *falciformis*.

EXTERNAL MORPHOLOGY.—Body cylindrical, elongate, slender, smooth; of about same diameter throughout, except in region of clitellum and extremities. Length of mature specimens (alcoholic), 6–9 mm.; maximum diameter (clitellar region), approximately 0.5 mm. Segmentation feebly marked externally, except in region of extremities. Surface between intersegmental grooves smooth; no secondary annulations. Somites, 32–48; average of eleven mature specimens, 42. Clitellum on 11–13; margins poorly defined; relatively thin; continuous about body. Setæ typically mesenchytræid; sigmoid; in four fan-shaped bundles per somite; 2–4 in lateral rows, 2–6 in ventral rows. Prostomium blunt, smooth, rounded. Head-pore on tip of prostomium. Color (alcoholic specimens), very light yellow. No evidence of pigmentation in body-wall.

INTERNAL MORPHOLOGY.—Lymphocytes sparse, small, scattered throughout coelom; loaded with granules, apparently pigmental. Brain about as long as wide; posterior margin very slightly concave; anterior margin distinctly emarginate, lateral margins straight and converging cephalad; close agreement with original figure by Eisen (1879, Pl. I, fig. 2d). Nephridia of typical mesenchytræid structure; anteseptal part composed only of nephrostome borne on short, slender pedicel; post-septal part enlarged, irregular, compressed; efferent duct arising from ventral surface near septum. Spermiducal funnel very small; length about twice diameter; collar small, flaring; sperm-duct short, thick, irregular, about 5–6 times longer than funnel; diameter of duct greater than that of funnel. Dorsal blood-vessel arising in 16; cardiac body apparently absent. Sperm-sacs two in number; short, extending only into 13; containing masses of sperm in mature specimens. Ovisac single; extending into 16. Penial bulb very small; simple, but one set of glands within bulb proper; apparently no muscle strands within bulb except at base; periphery of bulb covered with envelope of loosely associated gland-cells, exact relation of latter to bulb uncertain; atrium and atrial

glands absent. Spermathecæ small; short, confined to 5; simple; no diverticula; about same diameter throughout length; end blindly; no evidence of connection with digestive tract; no glands at ectal opening.

Discussion

CARDIAC BODY.—The apparent absence of the cardiac body in these specimens deserves comment. In spite of the good state of preservation of the material the writer has been unable to discover any structure in the dorsal blood-vessel which could be positively identified as the cardiac body. Its presence is usually regarded as one of the constant features of members of the genus *Mesenchytræus*. In the material studied by Michaelsen (1887, p. 370) this body was found to be thin, very slightly swollen, and composed of few cells. In the Greenland material the writer found a few hints of what may possibly be a very much reduced cardiac body but a definite conclusion was not possible.

PIGMENT.—Evidence of the presence of pigment in this species was found in the lymphocytes, which are heavily loaded with a dark granular non-staining material resembling that in the lymphocytes and certain other internal organs of some of the glacier enchytræids (Welch, 1916). One of the specimens shows a considerable amount of granular, non-staining material in the chloragog cells throughout the body. This material is in the form of minute particles, scattered more or less uniformly throughout the cytoplasm.

OVISAC.—In the original description, Eisen (1879, Pl. xv, fig. 46) appears to indicate the presence of two ovisacs which extend caudad into 16. Michaelsen (1887, p. 371) reported the ovisac as single, median, and extending into 19. In the Greenland material the ovisac agrees with Michaelsen's description, except that it extends only into 16. However, the distribution of the developing egg-masses is such that perhaps the apparent discrepancy between the accounts of Eisen and Michaelsen can be accounted for. In cleared, whole specimens the ovisac does appear as a double structure, one part on each side of the digestive tract, but a close scrutiny of serial sections reveals that while the ovisac is median in position the egg-masses lie in two more or less parallel, longitudinal rows to the right and left of the median line and at the medial line the dorsal and ventral walls of the ovisac are in very close proximity, often in actual contact. Thus a distinct double appearance is given in gross preparations and possibly Eisen's figure might have been based upon such a condition.

PENIAL BULB.—The penial bulb in this species seems to depart somewhat from the mesenchytræid type of structure which prevails throughout the genus *Mesenchytræus*. From the material at hand it has been very difficult to determine the finer details of structure and it may be that it represents a very simplified form of mesenchytræid bulb. The atrium, atrial glands, and accessory glands appear to be lacking. In serial sections the bulb consists of a distinct invagination of the body-wall surrounded by cells, apparently of one kind, which form the main body of the organ. The peripheral part of the bulb is composed of a loosely constructed layer of cells, seemingly glandular in nature, which merges into the wall of the sperm-duct. The writer has been unable to determine from these Greenland specimens the exact nature of this peripheral mass of tissue. It seems unlikely that it is some modified form of the atrial glands. Possibly it represents the peripheral gland-cells which appear in the bulb of certain species having the lumbricillid type of structure, but the line of separation between the two kinds of cells is very prominent—much more so than in lumbricillid bulbs. In some of the preparations there is distinct evidence that the muscles of the body-wall extend up along the line of division for a short distance. If this mass of loosely constructed tissue is really a part of the body of the bulb, then there is a small amount of muscle-tissue within the bulb at its base, thus resembling to some extent, the distribution of muscle-tissue in the penial bulb of *Mesenchytræus unalaskæ* (Eisen, 1905, p. 21, fig. 1e). The sperm-duct appears to empty directly into the penial invagination.

The structure of the penial bulb in this species seems to exhibit a departure from the definition of the genus (Welch, 1920), although the other characters are clearly mesenchytræid and there is no doubt as to the generic determination of the specimens. However, the condition of the material is such that the presence of much-reduced structures characteristic of the mesenchytræid type might not be recognizable. If such structures be present, they are exceedingly small.

***Mesenchytræus* species**

One collection made at Umanak, Greenland, June 1, 1914, contained nine specimens, all of which are badly contorted and represent various degrees of immaturity. Only three worms were sufficiently straight to permit sectioning or mounting and these constitute the only individuals which received detailed, internal examination. None of the three are completely mature and positive specific identification is, therefore, impossible. However, sufficient data were secured from both internal

and external characters to show definitely that the material belongs to the genus *Mesenchytræus*. In a number of respects resemblance to *Mesenchytræus falciformis* is evident, and it is possible that these worms may be immature stages of this species, since the collection was made at an earlier date than the foregoing one. However, there is nothing to indicate that the two collections were made in the same habitat since the only other information accompanying the material is that the specimens were found "in damp moss."

LUMBRICULIDÆ

The collections contained one specimen taken at Umanak, Greenland, July 2, 1914, from the bottom of a fresh-water lake. This specimen was submitted to Professor Frank Smith, of the University of Illinois, who kindly made the necessary identification and who furnished the following description.

Lumbriculus variegatus (O. F. Müller)

"The single specimen of this species in the collection is obviously incomplete posteriorly, and has 69 somites, with evidence of others in an early stage of development at the posterior end. The maximum diameter of the body is 1.06 mm.

"The specimen was not in a state of sexual activity, and the reproductive organs are only partially developed. Since the positions of these organs in this particular species are subject to wide variation, it is desirable to have records preserved of all accurately determined data concerning such positions. Spermaries and vestigial spermiducal funnels are present in somite 8, and what appear to be ovaries and vestigial oviducal funnels are present in somite 9. In the right side of somites 10 and 11, and the left side of somite 10 are very small structures resembling gonads, though probably at no time having such function. There are no recognizable atria nor spermathecæ, and their location cannot be determined with certainty.

"Eisen (1872, p. 122) has reported *L. variegatus* from Greenland, but the basis for the identification of the Greenland specimens with that species has been considered insufficient by some investigators. The same species has recently been reported (Smith and Welch, 1919, p. 4) from various localities in North America near the shores of the Arctic Ocean and has previously been known in similar latitudes in Europe and western Siberia."

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**Article XV.—BUDDING IN COMPOUND ASCIDIANS AND
OTHER INVERTEBRATES, AND ITS BEARING ON
THE QUESTION OF THE EARLY ANCESTRY OF
THE VERTEBRATES**

BY WILLIARD G. VAN NAME

It is one of the remarkable facts regarding the ascidians that, though they exhibit apparently unquestionable relationship to the highest group of animals, the vertebrates, and are classed with them in the phylum Chordata, many of them have an asexual method of reproduction in addition to the usual sexual one, namely, the power of production by gemmation or budding and of forming colonies of connected individuals, a habit which is found elsewhere only in certain of the most highly organized branches of the animal kingdom. In the older classifications it was customary to divide the ascidians into two primary divisions, the simple and the compound, according to whether they possessed this faculty or not, and, on account of its convenience, this method of dividing them is still in common use, though it is now well appreciated that the division is not a natural one. This is proved by the fact that some of the compound ascidians show much closer relationship to particular families of simple ascidians than they do to each other, a circumstance which has commonly been explained by the theory that the compound ascidians were derived separately from two or more groups of simple ascidians by separately and independently acquiring the power of gemmation. The writer himself formerly accepted this view, which has been and undoubtedly still is the one held by most of those who are specialists in the study of the Tunicata, as well as by other zoologists, and which is apparently implied in a statement by Hartmeyer, at present the greatest authority on this group of animals, as recently as the year 1908 (Sitzungsber. Gesell. Nat. Freunde Berlin, 1918, pp. 395-396), and by de Selys-Longchamps, who has made important studies of the budding of Ascidians as recently as 1917 (Bull. Sci. France-Belgique, p. 271), although the last-named writer briefly alludes to the fact that the opposing theory, that budding was an ancestral character of the tunicates, requires consideration.

According to the classifications of ascidians now in common use by the more progressive authorities, budding and the resulting colony-formation occur in about half the families; in a majority of cases, if it occurs at all in a family, it occurs in all members of it, but there are

certain interesting exceptions. The large and well-known family Styelidæ contains both simple and compound forms, too closely similar to each other in structure to deserve separation into two distinct families in spite of this important difference in their life history. They have, however, often been divided on this basis into two subfamilies, Styelinæ comprising the simple and Polyzoinæ the compound forms.¹ But, on closer examination, we find here within narrower limits relationships of the same nature that proved the division of all the ascidians into simple and compound forms an untenable one. Some of the Polyzoinæ are unquestionably more closely related to certain Styelinæ than to others of their own subfamily. There are certain compound forms which, though separated as the genus *Polyandrocarpa* from the simple genus *Polycarpa* on the basis of their habit of budding, are distinguished from the latter genus by no other character of more than specific rank. Exactly the same condition prevails in another family of ascidians, the Diazonidæ, not at all closely related to the Styelidæ. Here there are two commonly accepted genera, *Rhopalæa* and *Rhopalopsis*, of practically identical character except that the former is reported as not being known to reproduce by budding, while the latter does it, though single individuals are formed also.

Evidently, then, if the common theory is correct, the simple ascidians or some groups of them are probably still in processes of acquiring this new power; it must evidently have appeared very recently in such genera as *Polyandrocarpa* and *Rhopalopsis*, since they have not perceptibly differentiated from their simple allies. Why may we not expect it to appear in others now known only as simple ascidians and perhaps even to develop before our eyes? It would certainly be an interesting observation if we could detect its first origin in some genus or family in which it is as yet unknown.

It is evident that this theory presupposes a sudden or at least an exceedingly rapid development of the function of bud formation somewhat after the manner of a mutation, with either a complete suppression of, or a very rapid transition through, the intermediate stages. We know of no ascidians which habitually produce functionless or incomplete buds that may be regarded as an intermediate stage in the acquiring of the budding function, nor can we image how such incomplete buds could have a utility that would insure their continued production with an increasing approximation toward a perfection permitting of their functioning as

¹These subfamilies are no longer accepted in some of the latest works.

lividuals. The ascidians always have the faculty of budding in a fully functional degree or they do not have it at all.

If we compare the ascidians that produce buds with those that do not, we find that the former are almost universally characterized by two features, first, the individuals or zooids are of simpler and less specialized structure and, second, they are of much smaller size than in most of the simple ascidians. None of the members of the two most highly specialized families of the Ascidiacea, the Molgulidæ and Pyuridæ [Cynthiidæ of older classifications], which also contain many of the best species of ascidians, ever bud at all, while those few compound ascidians whose zooids attain a size approaching to or equalling the smaller simple ascidians, or approach the latter in the increasing complexity of their organization, exhibit the power of budding only to a limited extent, forming as a rule only small or rather small groups instead of the extensive colonies which the smaller and more simply organized compound ascidians ordinarily produce. The ascidians being, as their ontogeny shows, a degraded or degenerate group, descended from more highly organized ancestors, it has been assumed that the forms with the simpler, simply organized zooids were the result of the continued operation of the degenerating factors and that when the processes had gone far enough, reducing the animals to a condition corresponding to the members of some of the lower divisions of the animal kingdom, they became able, like these lower forms, to exercise the faculty of budding.

But, if we stop to consider the question, difficulties in accepting this convenient theory at once arise. How is an animal, even one no more highly organized than an ascidian, suddenly able to acquire the power of making buds? Of course the budding under consideration here concerns, like other forms of growth and development, of cell division accompanied by differentiation, under control of guiding influences the nature of which we do not understand, but the character of these controlling influences is, in the case of the budding of a complex multicellular animal, apparently much more complicated and even farther beyond understanding than in the case of those which govern the progressive differentiation taking place in the development of an egg into an embryo and eventually into an adult organism. If a mechanic is provided with the necessary tools and raw materials he may build a complex and serviceable machine, but give him the same machine and tell him to make two smaller yet serviceable similar machines out of it and he would very likely find it impossible. This illustration is only a remote parallel, but even if we were able to represent by a mathematical formula the

factors involved in the development of an egg into the adult, would not the representation of the budding of a complex multicellular animal into two or more similar ones require the introduction of additional unknown quantities into the equation which is already beyond our powers of solution?

The writer cannot believe that any ascidian or, for that matter, any of the numerous other invertebrates that reproduce asexually in analogous ways and form colonies of connected individuals ever suddenly "acquired" such a function, or that they now possess it unless they have continuously maintained it during the whole history of evolution, having inherited it from remote ancestors of such primitive structure that budding was then nothing more than cell division, and gradually developed the process in complexity as, in the course of their phylogenetic development, their own structure became more complex. Here, as in other cases, "*natura non fecit saltem*." Once an organism loses this function or allows it to remain latent during any period of extensive phylogenetic change and progress, it is improbable that the power can be secondarily acquired.

According to this view the simple ascidians have not given rise to the compound ones by a process of degeneration in size and in their complexity of organization. The indications are rather that budding was originally a faculty common to all ascidians and that the simple ascidians have lost that power.

Apparently, not only in the ascidians but in the other groups of invertebrates whose members bud and form colonies, an increase in the size of the individuals and in the multiplication and complexity of their anatomical parts beyond a certain point is accompanied by an abandonment of the budding function; in the coelenterates, for instance, forms with large individuals, as the sea anemones, are commonly simple, those with small individuals, as most corals and alcyonarians and, in another phylum, the Bryozoa, are generally compound.

This circumstance may, of course, be explained in at least two ways, that the increase in size and complexity of structure made the budding physically and physiologically more difficult, so that the power was eventually lost, or that the failure to divide into several or many small individuals made possible the larger growth and higher development of the single individual. Probably both these suppositions are correct and the causes have mutually interacted. Neither of them is opposed to the theory of the development of the simple from the compound ascidians.

The writer believes, therefore, that the power of the budding and colony formation, where it exists at all, is always a continuously maintained inheritance from the earliest ancestors of the group. The fact that, even in such a small and homogeneous group as the ascidians, several quite important modifications in the manner and details of the budding process have been shown to exist does not furnish such a strong argument for this function having arisen independently as a late acquirement as it might seem to at first sight. We cannot doubt that the Tunicata living today are the survivors of an ancient group formerly of much more importance than it is now, and that the ascidians and other subdivisions of it are also ancient groups. The great differentiation that is shown among the Tunicata, comparatively few as they are, indicates a long phylogenetic history, even though on account of their soft-bodied character we have not found them as fossils. There probably has been ample time for modifications in the process of budding within the group of ascidians. Neither is the fact that the most simply organized tunicates living today, the appendicularians, do not reproduce by budding any valid argument against the theory above advocated, as they have probably lost the function, because reproduction by budding is not a convenient process for animals of free-swimming or other active habits, the resulting interference with locomotion and obtaining food being evident. Therefore we see budding and colony formation retained (except in specially modified forms of the process such as occurs for instance in *Salpa*) chiefly in animals that have a permanently attached stage in their life history or an alternation of a fixed and a free generation.

The tunicates and the vertebrates being apparently of common origin, and in modern classifications included in the same phylum or primary division of the animal kingdom, the Chordata, the conclusions that we reach regarding the history of the Tunicata are not without interest as of possible bearing on the early history of the vertebrates, and it seems plausible that the chordate stock at the time of the separation of the tunicate and the vertebrate lines of descent still retained the habit of budding and colony formation which it had kept from its earliest beginnings. The ancestral vertebrates and later the appendicularians lost this faculty through their losing the fixed stage or generation in their life history and maintaining a free-swimming and active existence throughout their lives; more recently, the simple ascidians have also lost the faculty, in their case because of the increasing size and complexity of structure of the individual.

All permanently attached organisms and those which do not have some fairly efficient means of locomotion must provide not only for the reproduction but for the wider distribution of their species. The penalty for failure to do this is certain extinction. We find, therefore, in such organisms, a free-swimming or at least an easily transportable stage; sometimes there may be an alternation of generations between a fixed and a free-swimming form, but usually the distribution of the species is provided for at the time when it can most conveniently and effectively be done, that is while the individual is young and small; in the case of aquatic animals, by means of a free-swimming larval stage which the individual passes through immediately after hatching from the egg. Such a stage may be short or long; if it is prolonged, a development of the reproductive organs to a functional condition may occur and the animal may be able to reproduce without ever attaining the original adult attached stage. The latter, accordingly, becomes superfluous and may eventually be lost, and with it is lost also the power of asexual reproduction which may have been maintained in the attached stage. Apparently this is what has happened in the appendicularians among the tunicates and in the vertebrate branch of the chordate stock; possibly this process has been of still more general operation and many others of the Metazoa which lead a free and active existence may have arisen from the larvæ of attached forms rather than directly from ancestors leading an active existence throughout their life history. If we may base any speculations on the existing Tunicata, manifestly quite aberrant descendants of the original chordate stock, there was in the latter a prolonged larval free-swimming stage possessing such chordate characters as the dorsal central nervous system, notochord, and pharyngeal gill clefts; this stage alone has survived in the appendicularians and vertebrates. Both the larval and the attached stages have survived in the typical ascidians, though only in a degenerate and greatly altered form.

The conclusions to which this line of reasoning leads or to which it lends support may be summed up as follows.

1. The simple ascidians are not the ancestors of, but are derived from, the compound forms.
2. Reproduction by budding is a character originally inherited by the ascidians from their remotest ancestors, though it has since been lost by some of them.
3. Increase in size and complexity of structure and an active, free-swimming existence are two factors which cause loss of the faculty of budding.

4. Budding is not a faculty that can be acquired secondarily. It is a complex physiological and morphological process that must be maintained and gradually elaborated along with the phylogenetic development of the stock to which the organism belongs. If lost, it is lost permanently.

5. Other invertebrates, as coelenterates and bryozoans, that reproduce by budding and form colonies in a manner analogous to the ascidians, are governed by these same laws.

6. The ancestors of the vertebrates may have had, like the ascidians, a fixed adult stage capable of reproduction by budding; the existing vertebrates may be a development of the free-swimming larvæ of such organisms, not of the fixed stage.

7. That many of the existing groups of free-living animals may be the descendants of larval stages of attached forms. Attached organisms were probably much more numerous and important in the early period of the development of the animal kingdom than they are now.

Although the reader may not be inclined to agree with most of the hypotheses here advanced, the views above expressed concerning the relationships between the simple and compound ascidians seem too strongly supported by observable facts to be regarded as mere guesses, and the inquiry may naturally be raised as to why the opposite views are the prevailing ones and are accepted by at least a large majority of the most competent authorities.

The reason seems to be that the generally recognized connection between the ascidian and vertebrate stocks, coupled with the present insignificance of the ascidian branch as compared with the vertebrate branch, has led to the former being regarded a mere offshoot of the ancestral vertebrates, and those characters common to both branches (exhibited in the ascidians only in the larvæ) have been accordingly regarded as the only fundamentally important characters, while any others, such as the possession of an attached adult stage and the function of budding, have been regarded as secondary ones, both in significance and in date of acquirement. Added to this we have the merely incidental circumstance of the comparatively degenerate character of the adult ascidian, which tends to make the attached stage appear a secondarily acquired condition, leading us to forget that in their corresponding adult stage the ancestral ascidians of past ages may have been animals of much higher organization.

It is possible, then, that the compound ascidians of today may represent, in spite of their considerable degree of degeneracy, a nearer

approach to the ancestral vertebrates than is generally supposed, and that in our search for the earliest type of that most important phylum we must look for it in an attached colony-forming organism rather than in the worm-like form with which our hypothetical histories of the group usually begin. If the common ancestors of the existing Chordata had been of active habits throughout their life, the subsequent development of an attached adult stage in one group (the Tunicata) would not be remarkable, but we would not expect to find in it the power of reproduction by budding.

Article XVI.—ASCIDIANS OF THE WEST INDIAN REGION AND SOUTHEASTERN UNITED STATES

BY WILLARD G. VAN NAME

The subject of the present monograph is one that has been neglected by zoologists in recent times. Nearly twenty years have elapsed since the publication of the latest of the principal articles dealing with it, and here is no comprehensive work bringing together the scattered information which has appeared in various publications, many of them not easily accessible except to those having the use of an extensive scientific library.

It is hoped, therefore, that this article will accomplish a little toward filling a real deficiency in zoological literature and serve as a step toward later advances in the future.

The West Indian marine fauna, besides including the vicinity of the islands themselves, the Caribbean Sea and Gulf of Mexico, extends, though in diminished variety of species and with more or less admixture of forms from the colder latitudes, to include Bermuda and the American coast as far north as the vicinity of Beaufort, North Carolina, as well as the eastern coast of South America to near the southern boundary of Brazil. These should, therefore, be the proper geographical limits of this article but, as little has been recorded about the ascidians of the Atlantic coast from New York southward, this region has also been covered as well as the insufficient material at hand would permit. No collections from the east coast of South America have been available and very little has been published concerning its ascidians; that part of the region can, therefore, be only very unsatisfactorily dealt with here and still affords an almost new field for future collecting and study. The east coasts of Mexico and Central America and the northwestern part of the Gulf of Mexico have also been very insufficiently investigated, and even in the other parts of the region there are smaller sections which have been either entirely or partially neglected by collectors. Aside from all this, many of the known species are represented by material insufficient for the proper determination of their characters and distribution, and many of the descriptions given by the older writers are so deficient that their species cannot be recognized at present. It will, therefore, be appreciated that in the study of the ascidians of this region we have really only made a beginning, and that the present attempt to cover this large field will have to be supplemented by many additions and corrections in the future.

Review of Literature and Previous Work

The list of works and articles giving descriptions or first-hand information of the ascidians of the region this article covers is not a long one, though numerous other brief notices and references occur in various works and papers.

Lesueur, 1823, in an article entitled 'Descriptions of several new species of Ascidia' (Journ. Acad. Nat. Sci. Philadelphia, III), described ten forms, not all of which are recognizable from his descriptions and illustrations.

Stimpson, 1852 (Proc. Boston Soc. Nat. Hist., IV), added three more from the southern Atlantic States; his descriptions are brief and without illustrations.

Heller, 1878, in his 'Beiträge zur nähern Kenntniss der Tunicaten' (Sitzungsber. Akad. Wiss. Wien, LXXVII), described ten more West Indian forms, giving in many cases fairly detailed descriptions but illustrating only the external appearance.

Traustedt in 1882 and 1883 (Vidensk. Meddel. naturh. For. Kjöbenhavn, ann. 1881, 1882) published articles that even up to the present time remain the most important contributions to our knowledge of the subject. Seventeen species from this region are dealt with (not all of them new); his descriptions are detailed and accurate and his illustrations of the highest merit, leaving no difficulty in recognizing the species. These articles of Traustedt's are of a character to win increasing respect the more familiarity one has with the ascidian fauna of this region.

The preceding papers dealt practically exclusively with simple ascidians. The Challenger Expedition, though it did not collect in the West Indies, made stops at Bermuda and on the east coast of South America, and Herdman in his reports on the ascidians of that expedition (Challenger Reports, Zool., VI and XIV) records a total of thirteen species, mostly new, from the two regions; the majority of them are compound ascidians.

Sluiter (1898, Mém. Soc. Zool. France, XI) described or recorded twenty-seven species of ascidians, all but four of them simple forms, and mostly new species, collected by the Chazalie Expedition in various parts of the West Indies and on the northern South American coast. His descriptions and illustrations are by no means as full as those of Traustedt. Particularly striking is the large number of species of *Polycarpa* which he describes, a genus which in other West Indian collections has been only scantily represented as far as variety of species is concerned.

The Bermuda ascidian fauna has been dealt with in papers published by Verrill (1900) and by myself (1902).

Michaelsen (1908) in his studies of the collections in the Hamburg Museum has discussed the characters and relationships of certain of the West Indian species.

Hartmeyer, 1909-1911, completed the work on the ascidians in von Sars's 'Tier-reich' which was left unfinished by Seeliger and, in the part dealing with the geographical distribution, gives lists of the species from the West Indies, the Bermudas, and the eastern South American coast; also discussions of the relations of these faunas to those of other regions, which are valuable contributions to the literature of the subject. The lists are mainly compilations from the works of previous authors; although Hartmeyer has made extensive collections of ascidians in the West Indian region, he has published but little information of a systematic character regarding them.

References to a number of other papers and records of minor importance will be found in the lists of synonyms given in the descriptive part of the present article.

Material and Collections Studied

This account is based on an extensive series of specimens from Porto Rico, collected by Professor R. C. Osburn of Ohio State University and Mr. Roy W. Miner of The American Museum of Natural History in 1914 and 1915,¹ as well as on other West Indian material in that Museum; on collections made by myself at Bermuda and on the Florida coast, and on the collections in the Yale University Museum which were placed at my disposal for study, through the kindness of Professor W. R. Coe of that University. Many of the types and original specimens of the articles by Professor A. E. Verrill and myself on the Bermuda species, have been re-examined and the list of Bermuda species revised in accordance with the information which a study of the West Indian material now affords. The extensive series of specimens in the United States National Museum has also been gone over and has been of especial importance, not merely from its size and from its containing several new forms, but because it consists largely of dredged material, while in the other collections material obtained by collecting along the shores predominated, so that they were deficient in specimens from any but very shallow water. I wish to express my thanks to the staff of the National

¹Expeditions in co-operation with the New York Academy of Sciences and the Porto Rican Government.

Museum for the opportunity of studying these specimens, especially to Dr. Paul Bartsch, Curator of the Division of Invertebrates, and to Messrs. Waldo L. Schmitt and C. R. Shoemaker for the assistance and information kindly given me in dealing with this large collection. In addition to the above, material from various other sources has been examined, and my thanks are due to those who have collected or loaned it or otherwise assisted me, especially to Mr. Roy W. Miner of the American Museum, to whose interest and encouragement the carrying out of this work is largely due.

The areas best covered by the collections studied are the coasts of southern and western Florida, Bermuda, Porto Rico, Jamaica, certain of the Lesser Antilles (particularly the former Danish West Indies), parts of the coast of the Carolinas, and Chesapeake Bay, but many additional specimens from other parts of the region, as well as reliable records by other authors, assisted in making the survey of the subject more complete than the above statement would indicate.

The species represented are shallow-water forms or those characteristic of the continental shelf; only one really deep-water species (*Pyura antillarum* from 496 fathoms) was found in the collection.

The descriptive part of this article deals only with the species which I have myself seen and studied. These number fifty-five from the West Indian region proper and two additional species from the middle Atlantic states, to which must be added four forms or variations not regarded as sufficiently distinct to be treated as species. On account of the insufficiency of many of the descriptions it is uncertain how many of the other species that have been described from this region are valid and distinct from those dealt with here. A few are undoubtedly distinct; a majority are probably synonymous. No doubt some of the uncertainty will eventually be cleared up by a re-examination of the original specimens or by material collected in the type localities. Separate lists of species and forms known from the four parts of the region which have been the scene of the most thorough collecting are given at the end of this article, Florida being credited with 43, Bermuda with 31, Porto Rico with 26, and the former Danish West Indies also with 26.

Collecting in other places has not been sufficiently thorough for the preparation of local lists and, until more has been done in the southern part of the region (the South American coast and the islands near it), we must accept with caution conclusions that many species are found only in the northern part, though present records seem to indicate that this is the case.

Bermuda constitutes an isolated outlying district which many of the West Indian species do not appear to have reached; the compound ascidians are better represented there than the simple ones.

Relationships to Species of Other Regions

The relationships of the West Indian ascidians are, as would be expected, chiefly with those of other tropical and subtropical regions rather than with the faunas to the north and south, though with some overlapping of the ranges from or into the latter regions in the case of certain species. The most striking instance of such overlapping is *Ostrichobranchus pilularis*, which appears to range from the Gulf of St. Lawrence, if not from farther north, to the Gulf of Mexico, inclusive; at least I have been as yet unable to establish constant and reliable specific differences between northern and southern specimens. *Molgula sanhattenensis* and *Aplidium* (*Amaroucium*) *pellucidum* have similar but as extensive ranges.

The relationships between the West Indian ascidian fauna and those of the west coast of Africa and the Mediterranean are less close than might be expected, the identity of West Indian forms with those from one or both of the above regions having been certainly established in only six or seven cases, though there are other closely allied species that may prove to be identical and somewhat extend this list. It is to the fauna of the Indian Ocean, Red Sea, and Malay region that the most significant relationship exists.¹ We now know no less than eighteen species which are common to the West Indies and the Indo-Malayan regions, while in the case of several more of them there are very closely allied representatives that may eventually prove to be inseparable. The species in common are:

Polyclinum constellatum
Aplidium lobatum
Trididemnum savignii
Didemnum candidum
Leptoclinum macdonaldi
Cystodytes dellechiaiæ
Phallusia nigra
Phallusia sydneyensis
Rhodostoma pellucidum

Corella eumyota
Botryllus niger
Symplegma viride
Polyandrocarpa maxima
Polycarpa circumarata
Styela plicata
Pyura momus form pallida
Microcosmus exasperatus
Microcosmus helleri

¹Notice and discussion of this relationship, particularly as concerns the Red Sea species, is contained in a work of Michaelsen (Denk. Akad. Wiss. Wien., math.-nat. Kl., part 9, pp. 4, 5, 1919) which was not received until the present article was in type.

These species are mostly not known from the eastern side of the Atlantic, and none of them from the American side of the Pacific; their distribution is not circumtropical, but discontinuous. The West Indies and the Indian Ocean, inclusive of the Malay Archipelago, seem to be centers of ascidian faunas having too much similarity to be merely the result of accidental transportation and interchange of species, especially as the southward extension of the American and African continents and the cold subantarctic currents which flow along their western coasts would seem to be an almost insuperable barrier to the extension of the range of tropical forms. The close relationship of the faunas does not seem explainable without assuming some continuous warm-water communication within a comparatively recent geological time. Yet that such communication was through the Mediterranean is not indicated; more probably it was around South Africa.

The West Indian region is very much less rich in ascidians than the East Indian, even allowing for its smaller extent, for its having been less studied, and for the fact that the East Indian list undoubtedly contains a very large percentage of synonyms.

The ascidian fauna of the west coast of tropical America is as yet little known and no species is on record as common to it and the West Indian region.

Identification of Specimens

It is only recently that the great individual variability in ascidians of the same species and the very wide geographical distribution of a considerable proportion of the forms has begun to be realized. In the case of the compound ascidians especially, the number of valid species has apparently been greatly over-estimated. In certain genera of compound ascidians, such as *Trididemnum*, *Polycitor*, *Didemnum*, *Leptoclinum*, *Aplidium* (inclusive of *Amaroucium*), it is very hard to discover reliable characters for making specific diagnoses, so that, until more is known of their life history, of the details of their anatomy and development, and the effect of external influences on their growth and appearance, the species recognized must in many cases be regarded as provisional and likely to require more or less revision as our knowledge is increased. In cases where there has been an opportunity to study considerable series of specimens a great deal of variation is found, and it is evident that many of the characters which have been employed by authors to differentiate supposed species are of little or no value for such a purpose. It is questionable whether, in soft-bodied animals like the

ascidians, differentiation of the genera into a large number of slightly yet definitely separated species, such as occurs in insects and mollusks for example, is possible. If it can and does occur, we do not know how it may be manifested—certainly not in such characters as those on which many of the supposed species have been based.

The determination of specimens of ascidians is therefore often a matter of considerable difficulty, and it may be well to call the attention of those who use this and other works on the subject to the great allowance which must often be made for individual peculiarities, different degrees of contraction incident to preservation, and the variations in the degree of transparency, color and consistency of the tissues which depend on the physiological condition of the animal at the time of preservation, the strength and nature of the preserving fluids employed, and the presence of other material which may give off substances that discolor, shrink, or otherwise alter the tissues. In the simple ascidians many of the more important characters, as the number of folds and internal longitudinal vessels of the branchial sac, the size and number of component glands of the reproductive organs, etc., vary with the age and size (or both) of the individual. In this connection it must be remembered that size is influenced not only by age but also by environment and food supply, and that of two specimens the smaller one will often be the older and show more fully adult characteristics.

The shape of the body or colony and the character of its external surface are very liable to be affected by the environment, especially in those species which attach themselves in exposed situations, as on piles, rocks, etc. Other species, particularly those that bury themselves in the sand or mud, are more uniform in these respects, though the material in which they conceal themselves often affects the character and color of the test by adhering to it and becoming imbedded in it.

With a series of specimens at hand it is usually possible to recognize the characters of the species and to distinguish them from the variations due to the above-mentioned extrinsic factors; with but a single specimen this may be very difficult. Among the compound ascidians especially, many examples, because of unsatisfactory preservation, immaturity, poor development or degeneration, or from being in a quiescent stage of growth, present scarcely any diagnostic characters, and their positive determination may be difficult or impossible unless they happen to be found along with better specimens evidently of the same kind.

To so word a description as to cover all the numerous variations to which these soft-bodied animals are subject, both from internal and extrinsic factors, is manifestly impossible. Only the usual, well-developed, and normal can be described and illustrated, as otherwise the descriptions would be too long and too indefinite, and the mention of accidental individual peculiarities would obscure those of general occurrence and real importance. As a rule, the type of structure of the reproductive organs and branchial sac, with due allowance for possible immaturity or incomplete development, and for individual variations in the number of vessels and component parts of those organs, will be found to give the safest indications in identifying specimens of simple ascidians; in the compound forms the general habit of growth and the characters of the colony as a whole must be considered as well as the zooids, and also the stage in the life history of the colony, for in some species the colonies are known to pass through periods of degeneration in which many of the distinctive characters are lost or obscured. The practice of basing specific distinctions on the number of oral tentacles seems to be unwarranted; it is one of the characters most subject to variation with age and with the individual. Distinctions based on the form or stoutness of soft parts such as the lobes of the branchial, atrial, and anal apertures, the dorsal and atrial languets, etc., which change shape with the degree of contraction of the tissues, likewise appear to be practically worthless. The dorsal tubercle is subject to much more individual variation than has commonly been assumed. No general rule can, however, be given; a certain character may be very constant and of diagnostic importance in one genus or family, yet in another it may be entirely unreliable. While it is hoped that the descriptions and figures here given will enable those with a little zoological knowledge to identify most of their specimens, they must not expect to be always able to do so without dissection and microscopical examination of some of their material, and (especially in the compound species) without some perseverance in the study of the subject. Such analytical keys as have been given in other works usually prove total failures when tested.

Classification and Phylogeny of the Ascidians

The classification followed is substantially that adopted in recent works of Hartmeyer. Attention is called to the change in the application of the name *Tethyum*, which is here used for a section of the old genus *Halocynthia*, as Huntsman (1912) has shown to be required by the law of priority, *Pyura* being retained for the remaining members of the

genus. The names *Styela* and Styelidæ, *Molgula* and Molgulidæ, and *Polycarpa* are restored to use in their old and familiar applications (see Hartmeyer, 1914), a change which will certainly be welcome.

It will be observed that I have reversed the usually adopted order in treating the families and orders so that the compound ascidians precede the simple ones. This is because my present view regarding the relationships of the several families and orders is radically different from that which the generally adopted arrangement represents.

It can hardly be an unsafe statement to make that most zoologists, including a majority of those who have specialized in the study of the Tunicata, hold that the compound ascidians have been derived from simple ascidians by a decrease in the size and complexity of structure of the individuals and by the acquirement of the power of budding. All recent authors have, however, recognized the fact that some compound ascidians were more closely related to certain simple ones than to each other, and, to explain this, the assumption has been made that the power of budding has been independently acquired in two or more different groups of ascidians.

This hypothesis has become less and less satisfactory to me in the course of my studies of the Tunicata, since it is very difficult to imagine how an animal of apparently unquestionable relationship to the highest forms of animal life should suddenly acquire this extraordinary power, otherwise found only in the lower phyla. The advocates of the prevailing theory must assume that the function has developed very rapidly if not suddenly. We have examples of closely allied ascidians distinguished by characters of no more than generic or even specific importance; one member of these pairs of allied forms, however, produces buds and forms colonies, the other does not. Such instances are afforded by the genera *Polycarpa* and *Polyandrocarpa* in the Styelidæ, by *Rhopalæa* and *Rhopalopsis* in the Diazonidæ, and by the close relationships between the Phallusiidæ and Perophoridæ. Such pairs of closely related simple and compound genera would indicate, according to the usually accepted theory, that the budding power has been very recently acquired, since no other important morphological differentiation has since taken place. Moreover, were the process a gradual one, it would be expected to begin with the development of incomplete non-functional buds, and it is difficult to see how any utility could insure the continued production of such buds (with progress toward perfection) until a complete functional individual could be produced. As a matter of fact, we know of no ascidians habitually producing such rudimentary or imperect buds.

They have the power of budding fully developed and functional, or they do not have it at all.

The above-mentioned and other difficulties regarding the acquirement of this power are removed if we assume that budding was a function formerly possessed by all Tunicata; that it was inherited from ancestors so remote and so simple that their budding was nothing more than cell division; and that the physiological process has been continuously maintained and gradually developed in complexity as, in the phylogenetic history of the group, the morphological structure has become more complex and more highly organized. Certain of the ascidians have lost this function, perhaps largely on account of their increase in size and their development of a more complex organization (a similar loss of the budding function takes place in the large actinians), and I do not believe that groups in which the function has been abandoned or disused throughout any period of extensive phylogenetic development can again acquire it. Reproduction by budding being an inconvenient method for animals of active habits, owing to the increased difficulty of locomotion and obtaining food, it is not surprising that we do not find it retained in the appendicularians, and its loss or absence in that group presents no strong argument against the view here advocated.

An extended discussion of this question and of the conclusions to which it might lead, would be out of place in a systematic article of this character, but the above statement will indicate my reasons for changing the order in which the several groups are arranged and for abandoning the subfamilies Styelinae and Polyzoinae as an unnatural subdivision of the Styelidae. I have likewise united the Perophoridae and Phallusiidae, as their relationships are similar to those between the compound and simple Styelidae. I will only add that, if accepted, this view lends increased importance and a necessarily high degree of antiquity to the adult fixed stage of the ascidians, and no longer permits us to regard the latter merely as a comparatively lately acquired degenerative modification of a free-swimming type of organism.¹

Other departures from the now accepted classification are for the most part small and are sufficiently explained where they occur; they consist chiefly in the reduction of certain slightly distinguished genera to subgenera. Unfortunately, it seems necessary to take this course in the case of the well-known genus *Amaroucium*. Not only are the characters separating it from *Aplidium* Savigny, 1816, unimportant and variable,

¹See another article ('Budding in Compound Ascidians and Other Invertebrates, and Its Bearing on the Question of the Early Ancestry of the Vertebrates'), by the writer, in this volume (pp. 275 to 282)

but there are a number of intermediate species making any separation of the two genera a purely arbitrary one. Its retention in modern classifications is due chiefly to its long-established use for a number of well-known species, and to the belief that if the two genera were combined the resulting group would be "too large." The latter argument should carry very little weight. If there are large genera in nature there must also be large genera in our classification if it is to reflect nature; for the convenience of specialists these can be divided into subgenera or sections. For all who are not specialists large genera are vastly more convenient than small ones. If we recognize *Amaroucium* as distinct from *Aplidium*, most of the known species have to go in the former, so that we have one rather large genus anyway, unless indeed a large percentage of the supposed species prove to be synonyms, a probability which is by no means remote. It seems, therefore, to be time to reduce *Amaroucium* to the grade to which it is entitled, that of a subgenus or section; it has no place among genera distinguished by real and definite structural characters and it encumbers and impairs the natural character of our classification if so included.

Several genera of the Didemnidæ, though distinguished by better and more constant characters than *Amaroucium*, do not merit exception from similar treatment. Higher rank than a subgenus of *Didemnum* does not seem to be deserved by *Tetradidemnum* Della Valle, 1881, *Poly-syncraton* Nott, 1891, and *Leptoclinides* Bjerkan, 1905, although in previous articles I have employed them as genera. Of these, only *Poly-syncraton* is represented in the region covered by this article; the difficulty of separating it from *Didemnum* has already been noted by Hartmeyer, 1912a, p. 325. Even in its comprehensive sense, *Didemnum* will probably not prove to be a very large genus, since a very large proportion of its supposed species are apparently synonyms. Moreover, all these minor groups are retained as subgenera and the names remain as available as before for those who wish to designate the subdivisions which they denote or who prefer to use the subgeneric rather than the generic names as the first part of their binomials.

Nomina Conservanda

The confusion resulting from the brief diagnoses which were customary and the imperfect understanding of the nature and relationships of many of the marine invertebrates which prevailed during the early development of zoological nomenclature makes the application of the law of priority to the ascidians very uncertain and leaves the validity of many

important and familiar names more or less open to question. I fully agree with the belief of many that the law of priority alone, unsupported by the decrees of some body having internationally-recognized authority, cannot bring about stability of nomenclature. A list of *nomina conservanda* (Tunicata by Hartmeyer, Michaelsen and Sluiter) has been published by Apstein (1915), and extended and explained so far as the ascidians are concerned by Hartmeyer (1915). It is my belief that neither personal preferences for particular names nor prejudices against others nor animosity due to the late war should be permitted to stand in the way of attaining a stable nomenclature, and I would be glad to see this list of names authorized by the next International Zoological Congress. I cannot, however, see any justification for using a name that appears to violate the law of priority until after such authorization has been given. Nevertheless, I have in the present article called attention to the changes which the above list will make if adopted, by noting the proposed *nomen conservandum* (when different) under the headings of the several species affected.

The real importance of such a list of *nomina conservanda* is not the restoration of familiar names but the permanent preservation of names against being invalidated by objections raised against them in the future. Unfortunately, it affords no protection against the unrestrained splitting of genera which is practised by many zoologists, which has been carried to such an extent in some groups of the animal kingdom that the nomenclature has lost all the convenience and advantages that the binomial system should (and formerly did) afford. Nothing can protect us against such offenders but the exercise of good judgment and a determination to be governed in the acceptance of genera by the requirements of a nomenclature which will be convenient for general use. Its permanence should not be sacrificed on account of trivial considerations.

List of Species Described and Figured

As stated above, the descriptive part of this article deals only with the species that I have seen and studied. For additional species described by other authors the reader is referred to the alphabetic list of names and synonyms in the last part of this article, where references to the original description and other important literature are given.

The 57 species that are described are listed below. Seven of them *Didemnum fusiferum*, *Holozoa bursata*, *Polycitor (Eudistoma) hepaticus*, *Polyandrocarpa sabanillæ*, *Polyandrocarpa (Eusynstyela) floridana*, *Pyura antillarum*, and *Tethyum microspinosum*, are apparently new to science.

SYNOICIDÆ

1. *Polyclinum constellatum* Savigny, 1816
2. *Aplidium lobatum* Savigny, 1816
3. *Aplidium (Amaroucium) bermudæ* (Van Name), 1902
4. *Aplidium (Amaroucium) stellatum* (Verrill), 1871
5. *Aplidium (Amaroucium) pellucidum* (Leidy), 1855
- 5a. *Aplidium (Amaroucium) pellucidum* form *constellatum* (Verrill), 1871
6. *Aplidium (Amaroucium) exile* (Van Name), 1902

DIDEMNIDÆ

7. *Trididemnum savignii* (Herdman), 1886
- 7a. *Trididemnum savignii* form *poriles* (Van Name), 1902
8. *Trididemnum solidum* (Van Name), 1902
9. *Trididemnum orbiculatum* (Van Name), 1902
10. *Didemnum candidum* Savigny, 1816
- 10a. *Didemnum candidum lutarium* (Van Name), 1910
11. *Didemnum fusiferum*, new species
12. *Didemnum (Polysyncraton) amethystrum* (Van Name), 1902
13. *Leptoclinum macdonaldi* (Herdman), 1886
14. *Lissoclinum fragile* (Van Name), 1902
15. *Echinoclinum verrilli* Van Name, 1902

POLYCITORIDÆ

16. *Polycitor (Eudistoma) olivaceus* (Van Name), 1902
- 16a. *Polycitor (Eudistoma) olivaceus* form *obscuratus* (Van Name), 1902
17. *Polycitor (Eudistoma) convexus* (Van Name), 1902
18. *Polycitor (Eudistoma) hepaticus*, new species
19. *Polycitor (Eudistoma) clarus* (Van Name), 1902
20. *Polycitor (Eudistoma) capsulatus* (Van Name), 1902
21. *Clavelina oblonga* Herdman, 1880
22. *Clavelina gigantea* (Sluiter), 1919
23. *Cystodytes dellechiaiæ* (Della Valle), 1877
24. *Holozoa bermudensis* (Van Name), 1902
25. *Holozoa bursata*, new species

DIAZONIDÆ

26. *Rhopalæa abdominalis* (Sluiter), 1898

PHALLUSIIDÆ

27. *Perophora viridis* Verrill, 1871
28. *Ecteinascidia turbinata* Herdman, 1880
29. *Phallusia nigra* Savigny, 1816
30. *Phallusia hygomiana* Traustedt, 1882
31. *Phallusia sydneyensis* (Stimpson), 1855
32. *Phallusia curvata* Traustedt, 1882

RHODOSOMATIDÆ

- 33. *Rhodosoma pellucidum* (Stimpson), 1855
- 34. *Corella minuta* Traustedt, 1882

BOTRYLLIDÆ

- 35. *Botryllus schlosseri* (Pallas), 1766
- 36. *Botryllus* (*Botrylloides*) *niger* (Herdman), 1886

STYELIDÆ

- 37. *Symplegma viride* Herdman, 1886
- 37a. *Symplegma viride brakenhielmi* (Michaelson), 1904
- 38. *Polyandrocarpa sabanillæ*, new species
- 39. *Polyandrocarpa maxima* (Sluiter), 1904
- 40. *Polyandrocarpa* (*Eusynstyela*) *tincta* (Van Name), 1902
- 41. *Polyandrocarpa* (*Eusynstyela*) *floridana*, new species
- 42. *Polycarpa oblecta* Traustedt, 1883
- 43. *Polycarpa spongiabilis* Traustedt, 1883
- 44. *Polycarpa circumarata* (Sluiter), 1904
- 45. *Styela partita* (Stimpson), 1852
- 45a. *Styela partita bermudensis* Van Name, 1902
- 46. *Styela plicata* (Lesueur), 1823
- 47. *Styela atlantica* (Van Name), 1912

PYURIDÆ

- 48. *Tethyum microspinosum*, new species. [Possibly not West India]
- 49. *Pyura vittata* (Stimpson), 1852
- 50. *Pyura antillarum*, new species
- 51. *Pyura momus* form *pallida* (Heller), 1878
- 52. *Microcosmus erasperatus* Heller, 1878
- 53. *Microcosmus helleri* Herdman, 1881

MOLGULIDÆ

- 54. *Molgula occidentalis* Traustedt, 1883
- 55. *Molgula manhattensis* (De Kay), 1843
- 56. *Molgula lutulenta* (Van Name), 1912
- 57. *Bostrichobranhus pilularis* (Verrill), 1871

In addition to the forms listed above *Polycarpa fibrosa* (St 1852, a northern species, ranges southward in deeper water off into the latitudes covered in this paper. A poor and somewhat specimen is recorded from 39° 56' 30" N., 70° 59' 45" W., 238 See Van Name, 1912, under name *Pandocia fibrosa*.

Among the species of other authors not represented in the collections studied, the following seem deserving of special mention as not synonyms of any of the above (see references on pp. 483, 4

Corella eumyota Traustedt, 1882
Ascidella styeloides (Traustedt), 1882
Microcosmus anchylodeirus Traustedt, 1883
Molgula eugyroides Traustedt, 1883
Molgula contorta Sluiter, 1898

The following three species from New England are likely to be found to range southward along the coasts of the Middle States in shallow water on sandy bottom. See Van Name, 1912.

Molgula arenata Stimpson, 1852 (syn. *Cæsira arenata*)
Molgula robusta (Van Name), 1912 (syn. *Cæsira robusta*)
Molgula singularis (Van Name), 1912 (syn. *Cæsira singularis*)

DESCRIPTIONS OF SPECIES

The descriptions here given have been prepared from material from the region covered by this article and are not, except where indicated, based on the statements of other authors. The brief statements of some of the principal characters given under the headings of the families and genera are not intended as complete diagnoses but are for the convenience of those whose unfamiliarity with the classification of the ascidians would otherwise make it necessary to refer to other works for this general information. For a full statement of generic and family characters, the reader should consult Hartmeyer's work (1909-1911) in Bronn's 'Tier-reich,' III, supplement, pp. 1281-1773.

The text figures are from drawings by the author, and have been made somewhat diagrammatic. In the illustrations of the branchial sacs the folds are shown lying in their natural positions, hence covering partially or completely the flat intervals of the sac or, when the folds are very high, also the bases of the folds next above. The illustrations represent chiefly the internal parts but, as in the case of the external characters, the internal organs may exhibit great differences in appearance, size, and form due to different states or degrees of development and functional activity; this must be kept in mind when using such characters for the determination of species.

The external form and appearance of most ascidians varies so greatly and is so much modified by the conditions and circumstances of the preservation of the material that illustrations of the external features are generally but a poor guide in identification of specimens. Often, in fact, they are misleading. Such illustrations (reproduced from photographs) of many of the species here described will, however, be found in previous articles (1902, 1910, 1912, 1918) by the writer.

In view of the very detailed descriptions of certain compound ascidians (taking account of histological characters, minute differences in the size and shape of soft parts subject to contraction, etc.) that have recently been published, it seems worth while once more to call the readers' attention to the remarks regarding variability made on the preceding pages (see p. 288) and to state that the brevity of some of the descriptions here given is due to the large amount of material studied having shown the variability of such characters in specimens undoubtedly of the same species, and their unreliability or absolute uselessness in diagnosing species or identifying specimens.

Explanation of Lettering on Illustrations

<i>at</i>	atrial orifice	<i>l</i>	liver
<i>br</i>	branchial orifice	<i>lg</i>	languet
<i>ccl</i>	common cloacal aperture	<i>lv</i>	larva
<i>ecp</i>	endocarp	<i>mb</i>	muscle band
<i>em</i>	embryo	<i>mp</i>	muscular process
<i>en</i>	endostyle	<i>od</i>	oviduct
<i>g</i>	gonad	<i>oe</i>	œsophagus
<i>gc</i>	gastric cæcum	<i>r</i>	rectum
<i>ilv</i>	internal longitudinal vessel	<i>rf</i>	rudimentary fold
<i>in</i>	intestine	<i>sd</i>	sperm duct
<i>ing</i>	intestinal gland	<i>st</i>	stomach
<i>ip</i>	incubatory pouch	<i>trv</i>	transverse vessel
<i>k</i>	kidney	<i>vp</i>	vascular process

Order **APLOUSOBRANCHIATA** Lahille

[= *Krikobranchia* Seeliger]

Compound ascidians having the body divided into two or three distinct parts or segments (thorax, abdomen, and sometimes post-abdomen), the digestive tract and reproductive organs being situated in the posterior part or parts of the body. Tentacles simple; branchial sac without folds or internal longitudinal vessels.

Synoicidæ Hartmeyer, 1908

[= *Polyclinidæ auct. mult.*]

Body consisting of three divisions or segments, the last (post-abdomen) containing the reproductive organs and heart. Budding by segmentation of the post-abdomen.

POLYCLINUM Savigny, 1816

Post-abdomen a small oval sac connected by a narrow elongated neck with the abdomen. Stomach wall smooth, intestine twisted into a closed loop posterior to the stomach. Inner aspect of transverse vessels of branchial sac with small papillæ.

Polyclinum constellatum Savigny, 1816

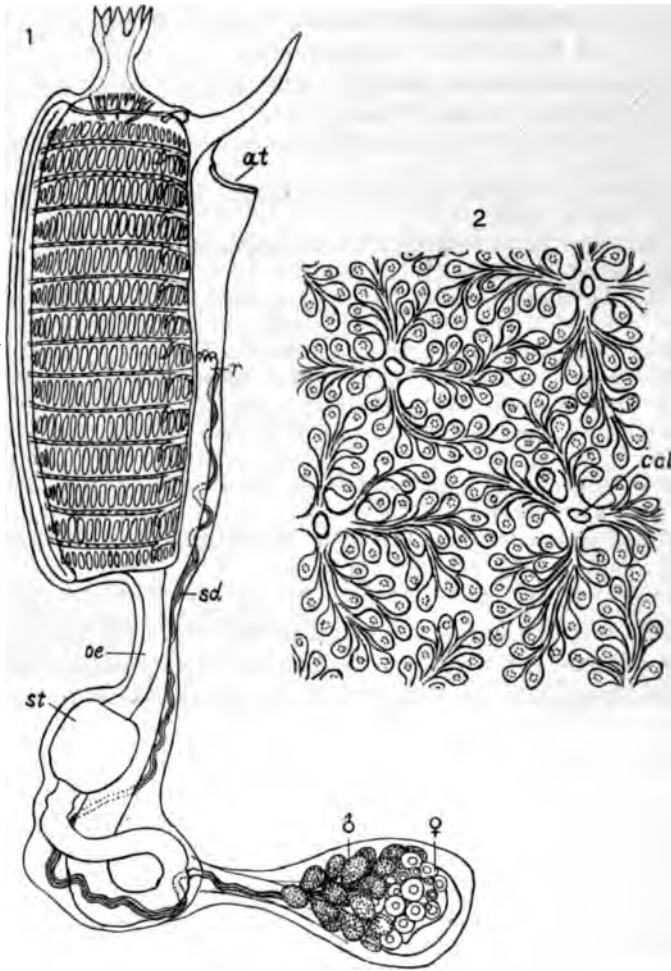
Figures 1 and 2

1816. *Polyclinum constellatum* Savigny, 'Mém. s. l. animaux sans vertèbres,' pt. 2, p. 189, Pl. iv, fig. 2; Pl. xviii, fig. 1.
1820. *Polyclinum constellatum* Savigny-Oken, Isis, pp. 660, 874, figs. on Pls. xii and xviii.
1891. *Polyclinum constellatum* Herdman, Journ. Linn. Soc. London, Zool., XXIII, p. 619.
1905. *Polyclinum festum* Hartmeyer, Zool. Jahrbücher, Syst., VIII, suppl., p. 401, Pl. xiii, figs. 6, 7.
- 1909-1911. *Polyclinum constellatum* + *P. festum* Hartmeyer, Bronn's 'Tierreich,' III, suppl., pp. 1461, 1640, 1641.
1912. *Polyclinum constellatum* Hartmeyer, 'Deutsch. Tiefsee-Exp.,' XVI, p. 334.
1916. *Polyclinum constellatum* + *P. festum* Hartmeyer, Sitzungsber. Gesell. naturf. Freunde, Berlin, ann. 1915, p. 429.
1918. *Polyclinum festum* Van Name, Bull. U. S. Nat. Mus., No. 100, I, p. 162, fig. 111.
1919. *Polyclinum constellatum* Michaelsen, Jahrb. Wiss. Anst., Hamburg, XXXVI, Suppl., p. 87.
1919. *Polyclinum constellatum* Michaelsen, Denkschr. Akad. Wiss. Wien, math.-nat. Kl., XCVII, part 9, p. 10.

For other possible synonyms see the above articles of Michaelsen (1919).

This species forms colonies of a grayish-brown color which, when of small or medium size, tend to assume a capitate oval or pyriform shape. The attachment is by the smaller end; the top may be rounded or more or less flattened. Larger colonies often become broader and sometimes even assume expanded and flattened or umbrella-like forms, but the area of attachment is usually small, so that much of the base of the colony, as well as the sides and top, are free, though the zooids are chiefly confined to the upper portions. In some cases the basal part of the colony tapers gradually to the size of the attached area, but a distinct pedicel is rarely developed, not even a very short one, the colony being sessile on the object on which it grows. Some colonies are cleft into two or more distinct lobes; these are perhaps often separate colonies that have grown together more or less at the base. Naturally, among the numerous examples collected, there are many which vary greatly in shape from the above-described usual types.

In all but the smallest colonies the zooids are arranged in several or many distinct systems. The small round or oval common cloacal orifices are scattered over the surface of the colony at distances of a centimeter apart, or less. Each orifice opens from a small common cloacal cavity, into which several branching cloacal ducts or groups of individual ducts open. These lead from the atrial orifices of the individual zooids; the



Figs. 1 and 2. *Polyclinum constellatum* Savigny, 1816

Fig. 1. Left side of zooid, $\times 30$. Fig. 2. Part of surface of colony showing arrangement of zooids and common cloacal canals, $\times 4.6$.

latter are arranged in short curved rows and clusters. The arrangement of the zooids and manner of branching of the cloacal ducts is shown in Fig. 2. In many specimens the anterior ends of the zooids, the small six-lobed branchial orifices, and the cloacal orifices, may be very distinctly seen on the surface, and the course of the cloacal ducts and the limits of the systems very easily followed. In other cases, at least in alcoholic material, some or all of these features may be greatly obscured by the

dark pigmentation of the test and the contracted condition of the colony. As already noted, the systems do not generally occupy the entire surface of the colony; on parts of the sides and on the lower portions near the area of attachment they are generally wanting.

The pear-shaped or ellipsoidal colonies become 30 to 40 mm. high and 30 to 60 mm. in diameter near the top, or occasionally larger. One very low but wide colony is 160 mm. across the upper surface, though no more than 18 to 20 mm. high at any point, its attachment being by a small central area on the lower side. Surface of colony generally smooth but not shiny, and generally free from incrusting sand; if a coating of sand is present, it does not pervade the interior of the colony to any considerable extent. Test usually dark-colored, of gelatinous consistency. In the alcoholic specimens, at least, it is much firmer toward the outside of the colonies than in the center, where it becomes very soft and there may be a large cavity. This, however, does not have any connection with the cloacal cavities. The dark color is due chiefly to pigment grains in the test cells and in some of the cells in the tissues of the zooids. A few colonies show, in the preserved state at least, very little pigmentation, and are yellowish or light grayish.

Zooids, when expanded and straightened out, 5 to 6 mm. long or more; the thorax, with the long branchial sac, occupying nearly half the total length of the body. The abdomen and the thorax are separated by a narrow neck, and the pear-shaped post-abdomen is also connected to the abdomen by a neck of considerable length. The post-abdomen arises from one side of the abdomen and generally lies with its axis more or less at right angles or at least very obliquely to that of the rest of the body.

Branchial orifice with six lobes, which are rather long and pointed except in greatly contracted specimens; atrial orifice a large plain-edged oval opening, from the front border of which a narrow pointed languet, extremely long in some individuals, has its origin.

Four first order, four second order and eight third order tentacles are present, and in well-preserved material fourth order tentacles can also be demonstrated in the intervals between the larger ones, making the normal number 32 when all are present. In some individuals, at least, the first order tentacle in the median dorsal position is larger than the other three.

Dorsal languets narrow and pointed, arising from the median dorsal vessel but fused with the transverse vessels of the left side of the branchial sac for a distance equal to the width of four or five stigmata so that they appear to arise from the transverse vessels.

Branchial sac with 14 to 18 rows of stigmata with from 19 to 22 stigmata in a row on each side of the body, except in the most posterior rows, where the sac becomes narrower and the number a little less. The transverse vessels bear very minute papillæ projecting inward into the cavity of the branchial sac; they do not correspond in number to the stigmata but are somewhat fewer, though arranged along the vessels with considerable regularity. They are probably to be considered as projections of the edge of a narrow membrane borne on the vessel, but in well-preserved material they are quite definite and well-marked structures, though very minute. These papillæ have been noted in other species and are probably present in all members of the genus, though it is difficult to demonstrate such delicate structures except in favorable material (see Hartmeyer, 1916, p. 427).

The digestive tract has the peculiar course characteristic of this genus, the intestine being twisted to form a small closed loop posterior to the stomach, which is smooth-walled. The rectum is rather long, extending to about the middle of the thorax, where it ends in a six-lobed aperture.

The anterior part of the post-abdomen is occupied by the male reproductive organs, which consist of a group of twenty or more small pyriform or oval testes. Their common sperm duct extends through the pedicel of the post-abdomen into the abdomen and then accompanies the intestine almost to the end of the rectum. The more posterior part of the post-abdomen contains the ovary, visible as a group of eggs in various stages of growth; the heart is in the extreme end.

Hartmeyer (1908, 1916) has already recorded this genus, but without naming any species, from Tortugas, Florida.

The genus is widely distributed in the West Indian region; in some places it is very common. Though very variable in form, size, pigmentation, and in the number of rows of stigmata in the branchial sac of the zooids, I can find no sufficient reason for believing that more than one species is represented, nor can I find characters upon which it may be separated from Savigny's species from Mauritius, except that Savigny's figure shows the number of tentacles as twelve instead of sixteen. In this genus, however, the tentacles appear to be normally in multiples of eight, not of six, and, as the tentacles are often difficult to count exactly, I cannot have confidence in this apparent difference. I also follow Michaelsen (1919a, p. 87) in identifying *P. festum* Hartmeyer, 1904, from Mauritius and the Philippines, with this species. The described species of this genus are mostly separated by very indefinite and untrustworthy

characters, so that it is not improbable that this form is more widely distributed than our present information shows.

The American specimens that I have examined are from the west coast of Florida (depths down to 26 fathoms), including Tortugas; off the north coast of Yucatan (24 fathoms); Bahamas; Cuba (Cienfuegos); Jamaica; Porto Rico (Guanica, on piles); and Sabanilla, Colombia. One specimen appears to have grown on a crab.

APLIDIUM Savigny, 1816

[= *Aplidium* + *Amaroucium* Milne-Edwards, 1841]

Post-abdomen (when fully developed) elongate, not separated from the abdomen by an elongate neck, though there may be a slight constriction between these two parts of the body. Stomach usually with distinct longitudinal plications; an atrial languet is present in all the West Indian forms.

Subgenus **APLIDIUM**

Distinguished by having the branchial sac short, with rather few (commonly five to ten) rows of stigmata, the post-abdomen short, the atrial aperture back from the anterior end of the thorax and often without a languet, and the testes in a more or less compact group (see Michaelsen, 1919a, p. 90) instead of an elongated series.

Aplidium lobatum Savigny, 1816

Figure 3

- 1816. *Aplidium lobatum* + *A. tremulum* Savigny, 'Mém. s. l. animaux sans vertèbres,' pt. 2, pp. 182, 184; Pl. III, fig. 4, Pl. XVI, figs. 1, 2.
- 1820. *Aplidium lobatum* + *A. tremulum* Savigny—Oken, Isis, pp. 660, 871, 872, figures on Pls. XII and XVII.
- 1909–1911. *Aplidium lobatum* + *A. tremulum* Hartmeyer, Bronn's 'Tier-reich,' III, suppl., pp. 1469, 1638.
- 1919. *Aplidium lobatum* Michaelsen, Jahrb. Wiss. Anst., Hamburg, XXXVI, suppl., p. 86.
- 1921. *Aplidium lobatum* Michaelsen, Denk. Akad. Wiss. Wien., math.-nat. Kl., XCVII, p. 22, figs. 11, 12.

The colony in this species is apparently normally of a rather thick incrusting type with rounded edges. The borders and surfaces show a tendency to be raised into low rounded elevations at many points or produced into more or less distinct rounded lobes. Greatest diameter of largest colony about 75 mm.; average thickness, where covering an even surface, probably not much over 3 mm. Zooids arranged in elongate groups and rows; the limits of the systems are hard to determine, but in large colonies, at least, they appear to be quite extensive and more or less

branched. The branchial orifices may or may not be slightly prominent on the surface; the common cloacal apertures are ordinarily inconspicuous in the preserved material. The test itself is rather transparent and nearly colorless or somewhat yellowish, but the colonies are rather opaque from the considerable quantities of sand which are present all through the test and assume more or less the color of the sand. This included sand renders the test rather firm but easily broken in the alcoholic specimens.

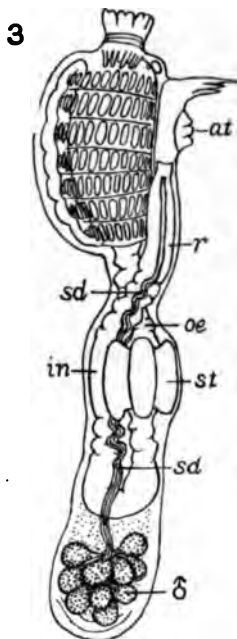


Fig. 3. *Aplidium lobatum* Savigny, 1816.
Left side of zooid, $\times 32$.

Zooids small and short; in the contracted condition found in preserved material not usually over 2 to 3 mm. in total length, or even less when the body is bent or distorted. Thorax short, separated by a constriction from the rest of the body; post-abdomen short and wide even when the reproductive organs are well developed.

Branchial aperture with six bifid lobes. Atrial aperture on the dorsal side of the thorax; less prominently lobed than the branchial aperture. Close in front of it is a small languet cleft into three pointed lobes.

Mantle musculature consisting mainly of the sphincters of the apertures and a few narrow longitudinal bands on the thorax.

Tentacles well developed, but the specimens were found too much contracted to determine the number.

Dorsal languets on the transverse vessels of the left side a little way from the median dorsal vessel.

About seven rows of stigmata (fairly long and narrow when the sac is expanded) with about fifteen or sixteen in a row on each side.

Stomach wall with five very deep furrows and the same number of very thick prominent longitudinal ridges. Intestinal loop quite long in well-expanded zooids.

Ovaries not developed in the individuals studied. Testes few in number (about fifteen to twenty) and forming a compact rounded group as is characteristic of this subgenus.

The American Museum collection contains a small colony dredged off Guanica Harbor, Porto Rico, in five fathoms. The National Museum

collection contains several larger specimens all dredged at St. Thomas, W. I. Savigny described it from the Red Sea. (Gulf of Suez).

Subgenus **AMAROUCIUM** (Milne-Edwards) 1841

Distinguished from the subgenus *Aplidium* by having zooids with a more elongate branchial sac and post-abdomen, and the atrial aperture placed well forward near the anterior end of the thorax. Atrial languet always present. Rows of stigmata numerous; testes arranged along the sperm duct in an elongate single or double series.

The species of this group show a great deal of individual variation in the form, color, and character of the colony, in the number of rows of stigmata in the branchial sac, and in the number of plications in the stomach wall, etc., and there is much difficulty in finding reliable and constant characters for separating them. The difficulties of dealing with the material are increased by the shrunken and poorly preserved condition in which much of it reaches the investigator, so that many of the essential characters of the zooids are often very difficult to make out. It is possible that more species should be recognized from this region than I have done. If so, I am at a loss to name the characters by which they can be satisfactorily distinguished. The question of the possible identity of some of these forms with those from other parts of the world cannot be dealt with on the basis of the material and information now available.

***Aplidium* (*Amaroucium*) *bermudæ* (Van Name), 1902**

Figure 4

1902. *Amaroucium bermudæ* Van Name, Trans. Conn. Acad. Sci., XI, p. 352, Pl. I, fig. 20; Pl. LVIII, figs. 96, 97.
1909-1911. *Amaroucium bermudæ* Hartmeyer, Bronn's 'Tier-reich,' III, suppl. pp. 1466, 1633.

This species was originally described from Bermuda (Van Name, 1902) from small capitate or wedge-shaped colonies, with rather abrupt sides and a rounded or flattened top. No large colonies were collected there. The Yale University and National Museum collections contain, however, much larger specimens that appear to be of this species from other localities. These large colonies vary greatly in shape; generally they are thick and massive, rounded or irregularly ovoid, sometimes compressed in one direction, but rarely to such an extent that they can correctly be termed plate-like. The area of attachment is generally small and variously situated, often near one end or on one of the narrower borders. The largest colony (from North Carolina) is a dome-shaped mass about 110 mm. by 60 mm. in diameter and about 70 mm. high.

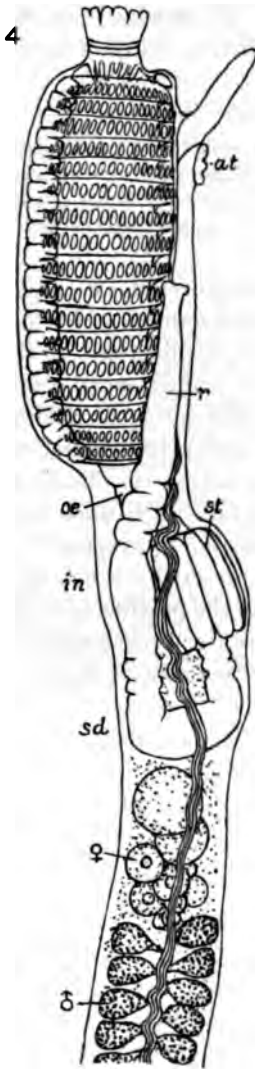


Fig. 4. *Aptidium* (*Amaroucium*) *bermudæ* (Van Name), 1902

Left side of zooid, $\times 25$.

Another (from southern Florida) is of somewhat flattened ovoid form, about 90 mm. by 50 mm. in diameter and over 40 mm. thick, attached by a small area on one of the broad sides.

Test rather firm, of somewhat cartilaginous character on the surface, but often softer in the interior. Surface usually, though not always, free from sand. In color the preserved specimens are usually yellowish, or brownish yellow, the zooids showing indistinctly through the test, which varies from merely translucent to semi-transparent. The Bermuda specimens, when fresh, were opaque grayish with a bluish or sometimes a pinkish cast; in preservation the test became more transparent. Zooids usually brightly colored, orange or in part vermillion red when alive; in preservation they fade to a dingy yellowish or brownish-yellow color. An arrangement of the zooids in systems cannot always be readily made out, but in some colonies they can be clearly seen to be arranged in small circular or oval systems, each surrounding a small common cloacal cavity and aperture. In preservation, owing to the greater contraction of these structures than of the intervening solid test, the surface of the colony becomes slightly depressed where they are situated, giving the surface a pitted appearance, but this is probably a purely artificial effect and would not be noticeable in fresh material under normal conditions.

Zooids usually rather large and stout. In a fairly well preserved, though nevertheless somewhat contracted, individual the body measured 3.3 mm. long, exclusive of the post-abdomen; the latter often measures 5 to 10

mm. additional. Branchial aperture with six (occasionally seven) somewhat bifid lobes. Atrial aperture usually also distinctly lobed and

provided just in front of its anterior margin with a long languet, usually of simple form but sometimes with a small lateral tooth or projection on each side. Mantle provided with strong longitudinal muscles which form distinct but rather narrow, closely placed bands on the thorax. These spread out and become diffuse on the abdomen, and mostly disappear on the post-abdomen.

Tentacles of at least two sizes, but difficult to count owing to the contracted condition of the material.

Dorsal languets arising from the transverse vessels a little way to the left of the median dorsal vessel.

Branchial sac elongate, with about sixteen or seventeen rows of stigmata in most colonies. There may be as many as eighteen stigmata in a row on each side. The rather large number of rows of stigmata appears to be one of the characteristics of the species, and I have found it to prevail in most of the specimens, yet in some colonies the number of rows seems to average smaller, only a dozen to fifteen.

Stomach unusually thin-walled as compared with its condition in the majority of species of this genus. Commonly it has a rather small number (generally from ten to eighteen) of longitudinal plications; these may be fairly sharp and distinct, but more often they appear rather faint, and in some colonies the stomach appears practically smooth-walled—a condition rare, if not unique, in this genus. The stomach is, however, generally found folded and crushed in by the contraction of the body muscles. Folds thus produced may generally be distinguished by their irregularity from the normal ones, though they are often so numerous and deep as to obscure the normal ones partially or entirely, or to produce in conjunction with them an apparent areolated or sacculated condition of the stomach wall.

Ovary situated as usual in the anterior part of the abdomen; the testes, which are very numerous in well-developed individuals, form a double longitudinal row along the sperm duct in the part posterior to the ovary.

Beside the types and cotypes from Bermuda already mentioned, the Yale University collection contains many colonies, several of them large, from Fort Macon, North Carolina, collected by Dr. H. C. Yarrow. Except small and not very characteristic (or perhaps somewhat doubtful) specimens from Water Island (in the former Danish West Indies) and Jamaica, the material in the National Museum collection is all from the coasts of North and South Carolina and from the Gulf of Mexico, mostly from the west coast of Florida. The depths of these stations are

generally not given; the greatest recorded is 14 fathoms, off the southern part of the North Carolina coast.

I have also assigned to this species several specimens consisting of small, closely crowded heads, densely incrustated with sand. They are from Cedar Keys, Florida, and from off the north coast of Yucatan (26 fathoms). Such specimens appear to bear the same relation to the ordinary colonies that the sand-incrustated *pellucidum* form of *A. pellucidum* bears to the *constellatum* form of that species, and they closely resemble the form *pellucidum* as described on p. 309 in the size and external appearance of the heads.

***Aplidium* (*Amaroucium*) *stellatum* (Verrill), 1871**

1871. *Amaroucium stellatum* Verrill, Amer. Journ. Sci., (3) I, p. 291.
1873. *Amarœcium stellatum* Verrill and Smith, 'Report on Invert. Animals of Vineyard Sound,' pp. 402 (411), 419 (424), 704.
1878. *Amarœcium stellatum* Coues and Yarrow, Proc. Acad. Nat. Sci. Philadelphia, p. 304.
1903-1911. *Amaroucium stellatum* Hartmeyer, Bronn's 'Tier-reich,' III, suppl., pp. 1467, 1619.
1910. *Amaroucium stellatum* Van Name, Proc. Boston Soc. Nat. Hist., XXXIV, p. 416, Pl. xxxiv, fig. 1, text fig. 25.
1913. *Amaroucium stellatum* Sumner, Osburn and Cole, Bull. U. S. Bureau of Fisheries, XXXI, pp. 75, 76, 159, 160, 733; chart 197.
1916. *Amaroucium stellatum* Pratt, 'Manual Common Invert. Animals,' p. 670.

For other references and a more detailed description, see Van Name, 1910.

This species forms flattened plate-like colonies resembling, when alive, pieces of raw pork in color and consistency. The colonies are very variable in shape, often long and narrow, sometimes divided into finger-like lobes; often they are shaped like disks attached by one edge. They become very large, sometimes as much as 300 to 600 mm. long, over 20 mm. thick and of very variable width. The edges are rounded; the zooids arranged in small circular systems, which in preserved specimens sink in, covering the surface with small depressions, but in life the surface is smooth, even, and shiny.

The zooids resemble those of *A. bermudæ*, though they appear to average a trifle smaller and generally to have fewer rows of stigmata (often only about eleven) with seventeen or eighteen in a row on each side. The stomach wall is, however, thicker and more rigid; it has usually about a dozen sharply defined longitudinal plications, which are not easily obliterated or obscured by the contraction of the body muscles. The discovery in the Yale University collection of the specimens on which Coues and Yarrow (1878) based their record of this

species from North Carolina (Fort Macon) now confirms the correctness of their statement. These specimens are said to have grown on piles; on the New England coast this species grows only attached to stones or gravel on the bottom where there is a strong current. This appears to be the most southern record of the species; a few possible specimens that I have seen from farther south I refer rather to *A. bermudæ*, a species which in some of its numerous variations sometimes approaches the present species in characters and appearance, including, though only rarely, the flattened form of the colony.

***Aplidium* (*Amaroucium*) *pellucidum* (Leidy), 1855**

Figure 5

1855. *Alcyonidium? pellucidum* Leidy, Journ. Acad. Nat. Sci. Philadelphia, (2) III, p. 142, Pl. x, fig. 24.

1871. *Amouroucium pellucidum* Verrill, Amer. Journ. Sci., (3) I, p. 290.

1871. *Amouroucium constellatum* Verrill, Amer. Journ. Sci., (3) II, p. 359.

This species, common and well-known on the southern New England coast, exists in two forms very different in external appearance, but not only connected by specimens intermediate in character but by colonies exhibiting in one part the characters of one form, in another that of the other in its extreme development. They are not, therefore, true subspecies.

In one form the colony is split up into a multitude of small heads of pyramidal or wedge-shaped form, each 5 to 10 mm. in diameter at the top, generally containing one small system of zooids and densely incrustated with sand, which is present also in the interior of the test. In the more perfect colonies of this form, these small heads are so closely crowded and fitted together as to give the whole colony the appearance of a rounded sand-incrustated mass several centimeters in diameter. In the other form the colony is not thus subdivided, though often cleft into a few larger lobes or heads; it is not incrustated with sand to any considerable extent, and the systems, though sometimes small and round or oval, often become large and of irregular outline. Verrill considered the two as separate species; he identified the sandy lobulated form with Leidy's *pellucidum* and described the massive sand-free form as a new species, *constellatum*. They have been treated as two species in most of the literature since that time. The massive or *constellatum* form appears, however, to be the usual manner of growth of the species, the other form developing chiefly on sandy bottoms where there is a strong current keeping the sand stirred up. The sandy form is, therefore, local in its

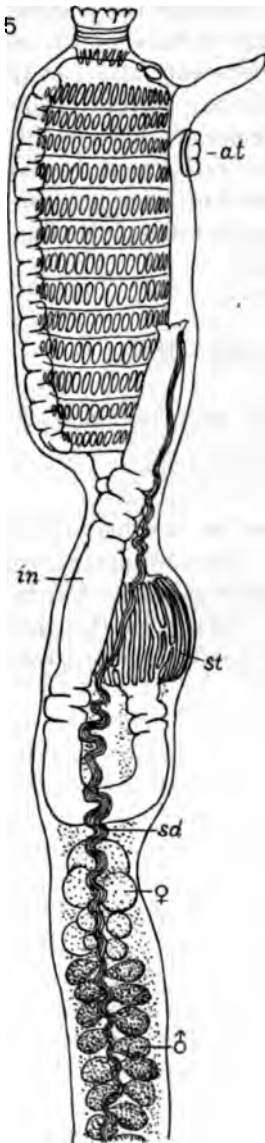


Fig. 5. *Aplidium*
(*Amaroucium*) *pellucidum*
(Leidy), 1855

Left of side zooid, $\times 25$.

distribution, and it is unfortunate that the species was described from it and that another name has become associated with the usual and more widely distributed form of growth.

Though Verrill and Smith (1873) report the sandy (*pellucidum*) form as ranging from North Carolina to Vineyard Sound, Massachusetts, most of the specimens from the southern states that I have seen are decidedly of the *constellatum* form, or, if intermediate, nearer to that form than to the extremely sandy and lobulated *pellucidum* as the latter occurs on the New England coast.

The chief references to this form are as follows:

- 1871. *Amaroucium constellatum* Verrill, Amer. Journ. Sci., (3) II, p. 359.
- 1873. *Amarœcium constellatum* Verrill and Smith, 'Rept. on Invert. Animals of Vineyard Sound,' pp. 704, 388, 393, 403, etc.
- 1910. *Amaroucium pellucidum* form *constellatum* Van Name, Proc. Boston Soc. Nat. Hist., XXXIV, p. 406, Pl. xxxvi, figs. 4, 5; Pl. xxxviii, fig. 9; text fig. 23.
- 1913. *Amaroucium pellucidum* form *constellatum*, Sumner, Osburn and Cole, Bull. U. S. Bureau of Fisheries, XXXI, pp. 155, 158-160, 733; chart 196.
- 1916. *Amaroucium constellatum* Pratt, 'Manual Common Invert. Animals,' p. 670.

For other references, including both forms of the species, see Van Name, 1910.

The normal shape of the colony of this form is that of a rounded or somewhat flat-topped head, tapering below to a rather narrow base or short peduncle; such heads may reach 15 to 25 mm. in height and be of very varying diameter. Larger colonies may consist of two or more such heads united at the base; very large ones may be quite broad (80 mm.) and of hemispherical or somewhat flattened cushion-like shape, though attached only by a small part of the

lower surface. Generally, however, large colonies, as well as many of the small ones, are of very irregular shape and are usually more or less divided into lobes by clefts of varying depth and width. In life the test varies from cream-color to pale orange or reddish; the zooids are brightly colored (largely orange-yellow, the stomach generally bright orange-red) and show more or less through the test, in spite of the latter being somewhat opaque. These bright colors fade out completely in alcohol. The consistency of the test and colony as a whole is generally rather softer and more flexible than that of *A. bermudæ*.

Zooids arranged in systems as above noted; they are of moderately large size (4 mm. or more long exclusive of the post-abdomen), which of course varies in length with age and the development of the reproductive organs. In most characters, they resemble too closely those of *A. bermudæ*, described above, to require a separate description; the number of rows of stigmata, however, appears to average less (9 to 15), and the atrial languet to always be of simple form without lateral projections.

The most conspicuous difference is in the stomach, whose wall has a much larger number (usually over twenty, sometimes between thirty and forty) of distinct but narrow longitudinal plications. These are generally somewhat irregular and interrupted in some places, often to an extent such as to cause an areolated condition of a part of the stomach surface. The species as a whole ranges from a little north of Cape Cod (Isles of Shoals, New Hampshire) to the west coast of Florida and the neighboring banks, and from near low-water mark to 26 fathoms. I failed to find it on the coast of southeastern Florida and its distribution may be discontinuous and interrupted by the southern part of the Florida peninsula.

***Aplidium (Amaroucium) exile* (Van Name), 1902**

Figure 6

1902. *Amaroucium exile* Van Name, Trans. Conn. Acad. Sci., XI, p. 354, Pl. I, fig. 21; Pl. LVIII, fig. 98.

1909-1911. *Amaroucium exile* Hartmeyer, Bronn's 'Tier-reich,' III, suppl., pp. 1467, 1633.

In addition to *A. bermudæ*, described above, there is also a smaller form found at Bermuda, which appears to be a distinct species. This forms small, rounded or button-shaped colonies, attached by the greater part of the lower surface. The edge or border of the colony is thick and rounded. Size up to 15 or 20 mm. across and 5 to 6 mm. high. Test colorless and transparent, but often more or less filled with sand grains and shell fragments, though some colonies are entirely free from such

included matter. In the latter case the zooids, which vary from orange to bright scarlet, are very conspicuous and make the colony a very pretty object. Consistency of test rather soft. Zooids small, the post-abdomen usually shorter than the remainder of the body; in the preserved and contracted state they are often not over 3 mm. in total length; sometimes not so much. Branchial aperture with six or seven lobes, atrial aperture plain or slightly lobed, and provided with a long languet of simple form at its anterior edge.

Tentacles of two sizes.

Dorsal languets borne on transverse vessels of left side a little way from the median dorsal vessel.

There are about a dozen rows of stigmata, with apparently from sixteen to eighteen in a row on each side. The number of rows is subject to a little variation in different individuals.

Intestinal loop of moderate length, usually twisted, in the contracted specimens at least.

Stomach rather thick-walled, with from ten to twenty narrow longitudinal folds (the number given in the original description was too few) that are sometimes slightly irregular or broken up into areolations on a part of the surface of the stomach.

Ovary in the anterior part of the post-abdomen; testes in the posterior part. Many of the zooids contain larvæ in the atrial cavity, these beginning the secretion of test substance while still within the atrial cavity of the parent.

The structure of the zooids shows that this species is a close ally of *A. pellucidum* of the Atlantic coast of the United States. It is common at Bermuda, growing on stones along the shore, as well as on corals, etc., in deeper water. There is also in the Yale University collection a specimen from Key West, Florida, collected by Prof. A. S. Packard, which may be of this species, though in my collect-

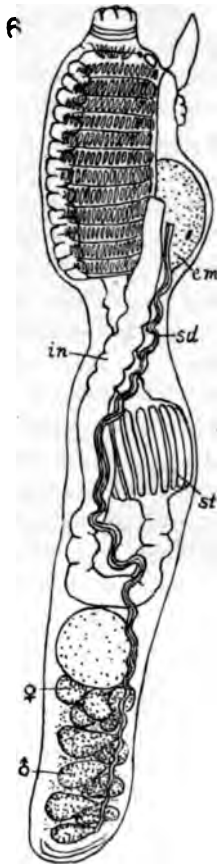


Fig. 6. *Aplidium*
(*Amaroucium*) *exile*
(Van Name), 1902

Left side of zooid, $\times 30$.

ing in southern Florida, I failed to find it, nor have I seen an undoubted specimen from any West Indian locality. The type is in the Yale University collection.

Didemnidae Verrill, 1871

Compound ascidians with minute zooids, having the body divided by a constriction into two parts (thorax and abdomen); branchial sac with only three or four rows of stigmata. They have a peculiar method of budding by which each new zooid grows from two buds (one for the thorax and one for the abdomen), arising from or near the constricted middle part of the body, so that characteristic double zooids with the two individuals joined together by the middle part of the body are temporarily formed.

Michaelsen has recently (1919a, 1920) called renewed attention to certain modified areas ("Seitenorgane" in his terminology) on the external surface of each side of the thorax of zooids of this family. These structures have been noted by many writers and are probably present in varying degrees of development in most members of the family, in some stages at least of their life history. They are oval or rounded areas, sometimes prominent on the body surface and definitely bordered by a raised rim, in other cases depressed below that surface or even deeply invaginated into the thorax; in the test adjacent to them or occupying their cavity, numerous very small spicules are commonly present. Dr. Michaelsen regards them as spicule-forming organs and likewise attributes to them considerable weight as specific characters, but the varying degree of their development in different specimens and their apparent absence in many cases suggests that they may be organs of a more or less temporary nature, so that further studies of their development and constancy will be needed before depending on them as specific characters. I regret that, owing to the delays and interruptions which have prevailed in the publication and distribution of scientific literature since the war, the above articles of Michaelsen were not received in time for me to include a study of these structures in the species dealt with in this article, but they should certainly not be neglected in any future investigations of this family.

TRIDIDEMNUM Della Valle, 1881

Distinguished by having three rows of stigmata, a single testis about which the sperm duct is spirally coiled, and often a short tubular atrial siphon, but no atrial languet. Stellate calcareous spicules present in the test.

As found in the West Indian region, the colonies of this genus are very variable in their minor characters, and the question of how many species should be recognized is not an easy one to settle. The larger series of specimens now available contains intermediate examples that make it necessary to unite certain forms treated as distinct species in my account of the Bermuda ascidians (1902).

Trididemnum savignii Herdman, 1886

Figures 7-9

1896. *Didemnum savignii* Herdman, 'Rept. Voy. Challenger, Zool.,' XIV, p. 261, Pl. xxxiv, figs. 1-5.
1891. *Didemnum savignii* Herdman, Journ. Linn. Soc. London, Zool., XXIII, p. 629.
1902. *Didemnum savignii* + *D. atrocanum* Van Name, Trans. Conn. Acad. Sci., XI, pp. 358, 359, Pl. LI, figs. 27, 30, 34, 35; Pl. LIX, figs. 112, 114.
- 1909-1911. *Trididemnum savignyi* + *T. atrocanum* Hartmeyer, Bronn's 'Tier-reich,' III, suppl., p. 1446, 1633.
1920. ?*Trididemnum natalense* + *T. savignyi* + *T. atrocanum* Michaelsen, Jahrb. Wiss. Anst., Hamburg, XXXVII, suppl., pp. 3, 6, text fig. 1.

This ascidian forms incrusting colonies, occasionally of considerable size (one specimen measures 75 mm. across) and of very variable thickness, usually only about 2 to 3 mm., but often considerably more when growing on an irregular surface. The external appearance of the colony is greatly dependent on two characters, both subject to very great variability in different specimens, first, the number and distribution of the large stellate spicules and, second, the abundance and distribution of the pigment cells in the test. The spicules are of comparatively large size, generally at least .04 to .06 mm.; in some colonies some of them are .08 or .10 mm. in diameter, or even more. They are generally beautifully regular in form, being stellate, with moderately numerous conical points which taper to a rather sharp extremity, though in many colonies among such regularly formed spicules there will be found many in which the points are irregular and broken or blunted at the tip. Occasional colonies occur in which the majority or all of the spicules exhibit such imperfections, the points being reduced to mere irregular protuberences on the spherical central portion of the spicule. In some specimens the spicules exhibit striking uniformity in size, in others large and small ones occur in varying proportions. Their distribution and relative abundance in the test are also subject to much variation. Generally the spicules are chiefly or entirely confined to a layer in the test a little beneath the upper surface, leaving the latter smooth and glossy. The spicules are often distributed in this layer in groups and patches, which may show white, in strong contrast to the dark areas where spicules are few or wanting, giving the surface of the colony a very conspicuously mottled or spotted coloration, but this occurs only in a small proportion of the specimens.

The branchial apertures of the zooids are usually distinguishable on the surface, though less conspicuous than in the form *porites* described below, and not raised above it as in that form; and the zooids themselves are often more or less distinctly visible through the test when they

mantle. The pigment is chiefly contained in special cells which are most abundant in the superficial parts of the test and vary in form from the most irregular and elongate shapes to regularly oval. Generally the pigment cells just described give the upper surface of the colony, or sometimes the whole test, a brownish or blackish color, according to their abundance; after preservation in alcohol for some time, this pigment becomes of a warmer brown tint. Bladder cells are usually very abundant, especially in the superficial parts of the colony.

The zooids show this to be a typical member of the genus. In the preserved material they vary from 1.5 to 1.6 mm. to less than 1 mm. in length, this being largely dependent on the state of contraction they are in. They have a tapering muscular process extending out into the common test from the constricted middle part of the body; its length and thickness are very variable in different colonies.

Branchial aperture with six short lobes. Atrial aperture round, situated on the dorsal side of the thorax at about the middle or somewhat farther toward the posterior end, the position varying in different colonies and often also in different individuals of the same colony. It is slightly produced, but usually not sufficiently to be called a tube.

Mantle with well-developed longitudinal muscle bands on the thorax.

Tentacles not less than eight, of at least two sizes arranged alternately, additional smaller third-order tentacles are probably present in the intervals.

Dorsal languets (two in number) borne on the transverse vessels of the left side, a little way from the median dorsal vessel.

Branchial sac with three rows of stigmata. The number in a row on each side in adult zooids appears to be variable. It reaches and possibly sometimes exceeds a dozen, but the number given in my previous description (1902), fifteen or sixteen, is too large. The sac extends a little posterior to the last row of stigmata, but this is not noticeable in strongly contracted specimens.

The rounded stomach and the other parts of the digestive tract present no peculiarities. The tubular organ of doubtful function which surrounds parts of the intestine in most ascidians is demonstrable in good material of this species and consists of a few delicate branching tubes which clasp the ascending part of the intestine where it passes the stomach.

Testis single, of conical form; the sperm duct arises from its apex and coils about it, often making as many as ten or twelve turns before

leaving it to accompany the rectum. The ovary, consisting of a very few eggs in different stages, lies near the base of the testis.

T. savignii was described by Herdman from a specimen obtained by the 'Challenger,' whose locality was marked as doubtful but probably from a station in 150 fathoms off the Cape of Good Hope. The close correspondence of Herdman's very detailed description with Bermuda and Florida specimens from shallow water suggests that the type may really have come from shallower water, and perhaps from Bermuda, where the Challenger Expedition also made collections. The American Museum contains specimens from Biscayne Bay, Florida, collected by myself, and one from off Salinas Cove, south coast of Porto Rico; the National Museum contains many from various points off the west coast of Florida from Cedar Keys to off Key West, also one from off the southeastern part of Jamaica. In American waters it grows on stones, shells, corals, gorgonians, etc., both along the shore at low-water mark and on the reefs and banks to depths of at least 27 fathoms.

The series of specimens now available indicates that *T. atrocanum* (Van Name), 1902, from Bermuda was based on immature colonies of the present form and is not a distinct species. *T. natalense* Michaelsen, 1920, from a tide pool at Isipingo, Natal, does not appear to be distinct from this species. Michaelsen gives only eight to ten as the number of stigmata in a row, while American examples certainly usually have more, but he may have made the count on immature zooids.

***Trididemnum savignii* form *porites* (Van Name), 1902**

- 1902. *Didemnum porites* + *Didemnum lucidum* Van Name, Trans. Conn. Acad. Sci., XI, p. 360, Pl. LI, figs. 26, 28, 29, 33, 37; Pl. LIX, fig. 115.
- 1909. *Trididemnum porites* + *T. lucidum* Hartmeyer, Bronn's 'Tier-reich,' III, suppl., pp. 1446, 1633.
- 1920. *Trididemnum lucidum* Michaelsen, Jahrb. Wiss. Anst., Hamburg, XXXVII, suppl., p. 6.
- 1921. *Trididemnum lucidum* Michaelsen, Arkiv för Zoologi XIII, No. 23, pp. 23, 24.

This form can claim only very doubtful validity as a species, and is so close to *T. savignii* that it seems better to regard it as a form of that very variable species. The zooids and spicules do not present any differences which make their description necessary; though the spicules average somewhat smaller, they are subject to the same variations in size and in the form of their points as in the typical *savignii*.

The chief differences are in the general character of the colony. Of the few specimens available, several reach a considerable size, in one case measuring about 90 mm. by 55 mm. across and 3 mm. or more

thick. The spicules are abundant and evenly distributed; often they are numerous in the superficial layer of the test, giving the surface a granular character. The branchial orifices of the zooids are usually very conspicuous and are slightly raised above the surface of the colony, which from these causes loses the smooth glossy character usual in typical examples of *T. savignii*. The abundance and more general distribution of the spicules give the test a grayish color and sometimes render it quite hard and brittle. Dark pigment is present in cells in the superficial part of the test and on the mantle of the zooids; in life it is black, the dark pigment and white spicules combining to give a gray color to the colony, which deepens to blackish where the pigment is thickest. In preservation this pigment usually remains quite dark, though assuming more or less of a brown or sometimes purplish shade.

Type locality, Bailey's Bay, Bermuda, growing on algæ. Type in the Yale Museum. The other specimens referable to this form that the writer has seen are from Florida (Cedar Keys, Salt Pond Key, and Stock Island), from the south coast of Porto Rico (vicinity of Cajo de Muertos, Guanica Harbor, and Parguera), and from eastern Jamaica, as well as a rather doubtful one from Andros Island, Bahamas. They are all from shallow water, and are preserved in the collections of the National and American Museums.

The additional material now available indicates that *T. lucidum* (Van Name), 1902, from Bermuda, was based on small and poorly pigmented colonies of this form and should no longer be regarded as distinct.

***Trididemnum solidum* (Van Name), 1902**

Figures 10-12

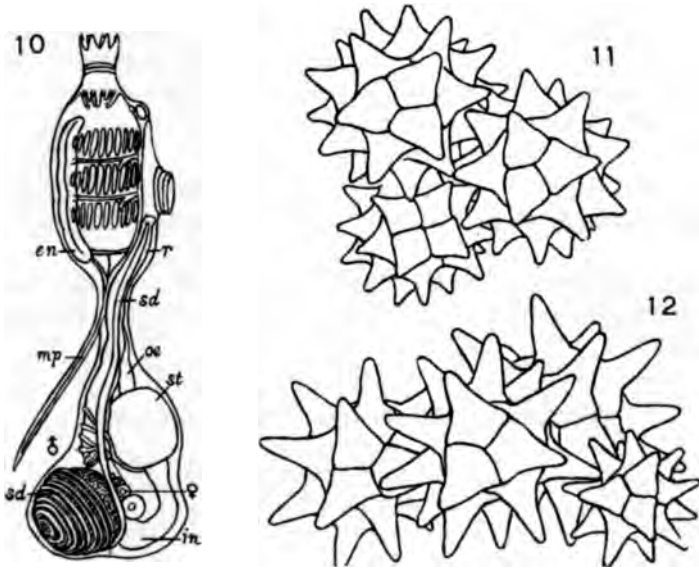
1902. *Didemnum solidum* Van Name, Trans. Conn. Acad. Sci., XI, p. 358, Pl. LI, figs. 31, 36; Pl. LIX, fig. 119.

1909-1911. *Trididemnum solidum* Hartmeyer, Bronn's 'Tier-reich,' III, suppl., pp. 1446, 1633.

This species was described from a single specimen now in the Yale University collection obtained at Coney Island, Bermuda, in shallow water. It is of irregular form, 45 mm. in greatest length, and 4 to 5 mm. in thickness in some parts, and incrusts a piece of seaweed. The test is rather hard and opaque, owing to the abundance of the spicules, which are quite uniformly distributed throughout the colony. During life it was of a pale reddish-gray color, almost a flesh-color, darker above; this faded in preservation to a yellowish white. Surface slightly raised over the position of each zooid; branchial apertures moderately conspicuous, not very close together. Spicules seldom exceeding .05 to .06 mm. in

diameter; they have quite numerous well-formed and regular conical points; the points are short and arise from a large central spherical mass. The individual points have the form of concave-sided cones and are thus rather narrow toward the apex in spite of having a broad base. Bladder cells few in most parts of the colony.

The zooids do not appear to differ materially from those of *T. savignii*, except in being rather small and slender and perhaps also in having somewhat fewer stigmata in the rows.



Figs. 10-12. *Trididemnum solidum* (Van Name), 1902

Fig. 10. Left side of zooid, $\times 60$. Fig. 11. Spicules of type colony from Bermuda, $\times 460$. Fig. 12. Spicules of a colony from Porto Rico, $\times 460$.

Among the Porto Rico material collected by the American Museum expeditions there are two good-sized colonies and one small one which agree well with the type of *T. solidum* from Bermuda in most characters. The larger colony incrusts a convex head of dead coral and would measure, if flattened out, about 130 mm. across and 4 to 5 mm. thick, or in some places even thicker. In its yellowish white color (in alcohol) and in the character of the surface and of the test it closely resembles the Bermuda specimen. The zooids likewise are elongate and slender and have only about eleven or twelve stigmata in a row on each side. Some of them have well-developed reproductive organs similar to those of

T. savignii, described above. The spicules in all the colonies are numerous and closely crowded; they average greater in diameter than those in the Bermuda type of *T. solidum*, sometimes reaching .07 mm. or even .08 mm. across the points. The points are much fewer and longer and slenderer than in the type colony, but quite regular and the spicules have in consequence a very symmetrical stellate form. These Porto Rican specimens were dredged south of Guanica on sandy bottom with coral rocks and algæ, in depths of about 23 and 35 fathoms, and between Cajo Caribe and Cayo Parguera in 5½ to 8 fathoms. The National Museum contains similar specimens (also with rather long-pointed spicules) from the Bahamas, collected by B. A. Bean, 1903, and from Mosquito Bay, St. Thomas, collected by C. R. Shoemaker, also several very large ones from St. John (former Danish W. I.), growing on millepore corals, collected by Mr. Shoemaker. One of these is 250 mm. in maximum length, covering a flattened branch of the coral on both sides and having a maximum width of over 80 mm., but it is not very thick at any point.

This species is evidently closely allied to *T. savignii*, especially to the form *porites*, and its distinctness cannot be regarded as very well established.

***Trididemnum orbiculatum* (Van Name), 1902**

Figures 13-15

1902. *Didemnum orbiculatum* Van Name, Trans. Conn. Acad. Sci., XI, p. 361, Pl. LI, figs. 32, 38; Pl. LXI, figs. 127a, 128.

1909-1911. *Trididemnum orbiculatum* Hartmeyer, Bronn's 'Tier-reich,' III, suppl., pp. 1446, 1633.

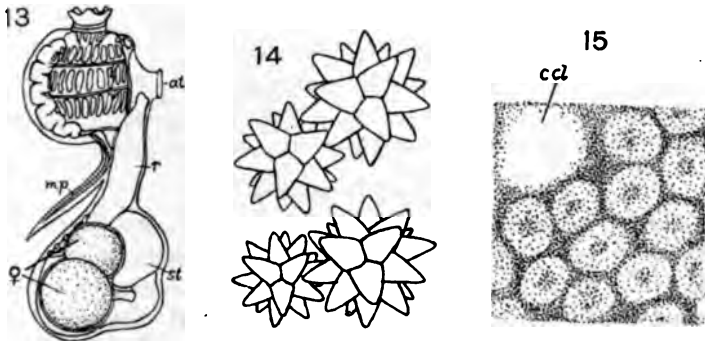
1916. *Didemnum orbiculatum* Pratt, 'Manual Common Invert. Animals,' p. 671.

1921. *Trididemnum orbiculatum* Michaelsen, Arkiv för Zoologi, XIII, No. 23, p. 24.

Colony (in contrast to that of *T. savignii*) always very thin, flat and incrusting, translucent; during life of a characteristic light slate-gray color fading to almost white on preservation. Size of the largest specimens 25 to 30 mm. across and 2 mm. or less in thickness. Surface smooth in fresh specimens; in preserved material often uneven and raised over the positions of the zooids, which are usually quite thickly and evenly distributed, and are more or less concealed by a rather dense layer of spicules in the upper stratum of the colony. The spicules are so distributed that the surface of the colony usually shows over the position of each zooid a circular or oval area of about the diameter of the thorax, more transparent than the intervening spaces, which latter are whiter and more opaque, owing to the greater abundance of spicules there.

Spicules mostly between .035 and .04 mm. in diameter, quite regularly stellate, with a moderate number of rather long points of fairly regular tapering conical form.

Zooids very small, often only 1 mm. long when much contracted. Usually there is much blackish pigment in the cells of the mantle in the thoracic region. Branchial orifice six-lobed; atrial orifice almost plain-edged, without a languet. It is situated either opposite the middle of the thorax, or farther toward the posterior end, and is produced into a very short tube. A strong muscular process extends back into the common test from the constricted middle region of the body.



Figs. 13-15. *Trididemnum orbiculatum* (Van Name), 1902

Fig. 13. Left side of zooid, $\times 40$. Fig. 14. Spicules, $\times 460$. Fig. 15. Part of surface of colony showing distribution of spicules in superficial layer of test, $\times 15$.

Strong sphincters are present about the apertures and many strong longitudinal muscle bands on the thorax, which so contract that part of the body that a satisfactory study of the internal parts becomes very difficult.

There is a total of at least eight tentacles of two sizes; possibly additional smaller ones may be present.

Three rows of stigmata with probably not over eight or ten in a row on each side.

No peculiarities in the alimentary organs were noted; stomach rounded; intestinal loop small.

Although zooids from many colonies collected in April and May were examined, no male reproductive organs were found. (Specimens of *T. savignii* collected at that season usually have them well developed). Many of the zooids, however, contain one or two large eggs in the abdomen.

This species is known only from Bermuda, where it was found common on the under side of large stones at many points along the shore, especially at Long Bird Island, Waterloo, and Castle Harbor, growing in company with other ascidians such as *Didemnum*, *Lissoclinum* and *Botryllus*.

As a considerable number of specimens were obtained, all very constant in their characters and quite different in appearance from *T. savignii* during life and in preservation, it seems likely that this is a valid species in spite of the variability shown to exist in *T. savignii* by the material now available.

The type is in the Yale University collection.

DIDEMNUM Savigny, 1816

[= *Leptoclinum* auct. mult.]

Four rows of stigmata in the branchial sac. Proximal part of the sperm duct wound spirally about the testis. Calcareous spicules present in the test.

Subgenus **DIDEMNUM**

Atrial orifice not produced into a tube and usually without a languet. Testis single or divided into not more than two lobes or separate glands.

The white or yellowish (sometimes reddish) colonies of animals of this group, which incrust stones, sponges, algæ and other objects, and are often so densely crowded with minute spherical or stellate spicules as to become hard and brittle, are common in many parts of the world. Under the wrongly applied name *Leptoclinum* Milne-Edwards, they are familiar to nearly everyone who has collected marine invertebrates. Their systematic treatment involves many difficulties. The colonies are too opaque to study in a living state, and the zooids are minute and exceptionally hard to preserve except in a violently contracted condition that makes a study of the organs difficult. Such features as the character of the surface of the colony, whether smooth or wrinkled, whether the apertures and the systems in which the zooids are arranged are conspicuous or obscurely visible, or differences in the size of the zooids or in the proportions and shape of their soft parts are not reliable as specific or even varietal characters. Many such apparent differences are due to varying states of muscular contraction or varying degree of shrinkage incident to preservation, or to modifications due to the immediate effect of the conditions under which the colony grew. Differences in the spicules of the colonies exist, but with a large series of specimens at hand such a complete gradation between the extremes is shown that these differences lose most of their weight, and I have been forced to the con-

clusion that most of the members of the subgenus *Didemnum* inhabiting the Atlantic Coast from southern Massachusetts southward to Brazil, including Bermuda and the West Indies, as well as a large proportion of the supposed species described from the warmer parts of the Old World, belong to one variable species. For this the specific name *candidum* Savigny, 1816, appears to have priority. The evidence seems to be increasing that, instead of *Didemnum* being one of the largest genera of ascidians, the members of it which can be distinguished by any reliable and constant characters are in reality few, though in some cases widely distributed geographically.

Didemnum candidum Savigny, 1816

Figures 16-25

1816. *Didemnum candidum* Savigny, 'Mém. s. 1. animaux sans vertèbres,' pt. 2, pp. 14, 194, Pl. iv, fig. 3; Pl. xx, figure 1.
1886. *Leptoclinum speciosum* + *L. s. var. asperum* Herdman, 'Rept. Voy. Challenger, Zool.,' XIV, pp. 274, 277, Pl. xxxiv, figs. 8-13; Pl. xxxvi, figs. 1-9.
- ?1886. *Leptoclinum annectens* Herdman, 'Rept. Voy. Challenger, Zool.,' XIV, p. 280, Pl. xxxiv, fig. 14; Pl. xxxviii, figs. 5-9.
1891. *Leptoclinum speciosum* + *L. s. var. asperum* Herdman, Journ. Linn. Soc. London, Zool., XXIII, p. 631.
1897. *Leptoclinum speciosum* var. *aspera* Sluiter, Zool. Jahrb., Syst., XI, p. 39.
1902. *Leptoclinum speciosum* + varieties, Van Name, Trans. Conn. Acad. Sci., XI, p. 363, Pl. LII, figs. 39, 42-52; Pl. LXI, fig. 127; Pl. LXII, figs. 130c, 132, 134-136.
- 1909-11. *Didemnum speciosum* + varieties Hartmeyer, Bronn's 'Tier-reich,' III, suppl., pp. 1450, 1633, 1634.
1920. *Didemnum speciosum* Michaelsen, Jahrb. Wiss. Anst., Hamburg, XXXVII, suppl., p. 32.
- See also Michaelsen, Abhand. Nat. Verein, Hamburg, XXI, pt. 1, p. 23, 1919.

The above list includes only synonyms and references applying to this species as found in the region covered by this paper. See also p. 331.

[The following also belongs to this species but is probably distinguishable as a subspecies or geographical race.

1910. *Didemnum lularium* Van Name, Proc. Boston Soc. Nat. Hist., XXXIV, p. 371, Pl. xxxvii, fig. 7, text figs. 8, 9.
- 1909-11. *Didemnum lularium* Hartmeyer, Bronn's 'Tier-reich,' III, suppl., p. 1741.
1911. *Didemnum lularium* Sumner, Osburn and Cole, Bull. U. S. Bureau of Fisheries, XXXI, p. 731; chart 194.
1912. *Didemnum lularium* Hartmeyer, 'Deutsch. Tiefsee-Exp.,' XVI, p. 326.

For a discussion of the synonyms and distribution of this form see Van Name. 1910.]

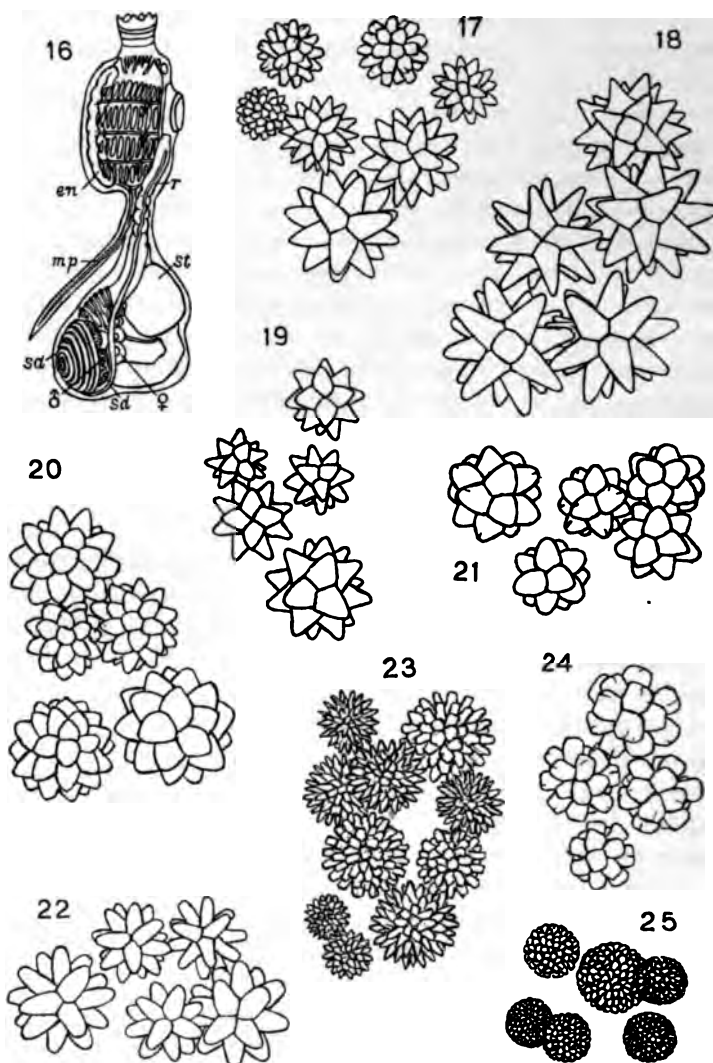
Colony of the incrusting type, usually thin (not over 2 or 3 mm. thick), though sometimes measuring 60 to 70 mm. across or occasionally considerably more. When growing on uneven objects, its thickness in some places may become considerably greater than above stated. This is its usual form of development when growing on a continuous surface as a stone or a shell, but often it grows on an irregular branching object, as a gorgonian, hydroid, or branching sponge. In such cases it surrounds the branches and often binds together or incloses two or more of them. As it grows larger it may finally entirely envelop the object, covering all its branches and assuming more or less its form. Such colonies are intermediate between the usual incrusting form and certain other peculiar ones that at first sight might be taken for a different species. These latter have the form of large rounded or dome-shaped masses with a deeply convoluted and plicated surface penetrated in different directions by numerous clefts, canals and passages of various diameters, giving the colony as a whole a sponge-like character as far as its shape is concerned. There are zooids opening on the walls of the clefts and canals as well as on the outer surface. The National Museum contains such colonies dredged at stations in the Gulf of Mexico in water down to 28 fathoms deep, that measure 100 to 130 mm. in diameter. I regard such colonies as resulting merely from the original attachment of the colony to an object of complex branching form as a hydroid, alga, or perhaps a sponge, which in course of time the ascidian may entirely inclose and kill, the different lobes of the ascidian colony finally uniting where they approach close together but leaving many clefts and canals between them, thus forming the sponge-like colony. Similar forms occur in the Malayan representatives of this genus (see Van Name, 1918, p. 148), and Sluiter (Siboga-Exp., LVIb, p. 67) has described a species, *D. spongioides*, on the basis of such a colony-form, a course which does not seem justified.

Color usually white, sometimes very pure white, in other cases yellowish or less frequently reddish; in turbid waters more or less discolored with mud. Borders of the colony varying from thin to thick and rounded, surface very variable, sometimes quite even, in other cases much wrinkled. The surface, if comparatively free from spicules in the extreme superficial part, may be somewhat glossy and smooth to the touch, but any abundance of spicules there renders it a dead white and makes it feel slightly gritty. When the spicules are abundant, the zooids, which are yellow or in parts orange during life, may be entirely concealed, unless their branchial apertures are expanded, but their positions are often indicated by a small, low, rounded elevation over the anterior end of each

zooid. When less abundant the spicules are often chiefly gathered in the upper layers of the colony, leaving the deeper portions of the test yellowish and translucent and the colony comparatively soft. In some colonies the branchial apertures are conspicuous in the preserved condition and each is surrounded by a minute circle of more densely crowded spicules within which the six-lobed character of the aperture is indicated by six minute groups of very small spicules between the lobes. (This is, however, not always demonstrable, and is not peculiar to this species.) Bladder cells are present in the test in varying quantity; their number or distribution does not appear to afford a diagnostic character. The systems in which the zooids are arranged are complex, and except in small colonies a number of common cloacal apertures are present, though in preserved material these are usually by no means easy to demonstrate. Different colonies vary very greatly in respect to the clearness with which these systems and the courses of the common cloacal ducts show on the surface. These features may be very conspicuous, so that the zooids are seen to be arranged in branching and curving lines, or they may be impossible to follow out, the zooids appearing to be merely scattered irregularly in the superficial part of the colony.

The varying abundance and distribution of the spicules, which are of spherical stellate form, have already been noted. It should be added that colonies growing on hard rigid objects (corals, stones, mollusk shells, etc.) usually have the most abundant and uniformly distributed spicules, and become very rigid and brittle, as there is no necessity for any movement or bending of the common test except to permit of the expansion of the zooids. Those growing on soft sponges, flexible plants, etc., which do not provide a rigid and immovable support, are more apt to have the spicules less closely placed, giving a more flexible colony capable of yielding to movements of the supporting surface.

In some colonies the spicules exhibit very striking uniformity in size, in others they are of various sizes, which may be present in varying proportions; occasional abnormally large spicules ("giant spicules") may be found in a few specimens. The usual diameter of the spicules varies in different colonies from .025 mm. (sometimes even less) to about .04 or .05 mm.; rarely more. Commonly there is within a single colony great uniformity in the shape of the spicules, as well as in their size; different colonies, even those growing side by side on the same stone, may differ conspicuously in the type and average size of their spicules. The illustrations here given (Figs. 17-25) show typical groups of spicules from different colonies and illustrate the principal modifications that occur,



Figs. 16-25. *Didemnum candidum* Savigny, 1816

Fig. 16. Left side of zooid, $\times 40$. Figs. 17-25 inclusive, spicules from different colonies, $\times 460$. (Fig. 19 represents spicules of subspecies *lularium*).

except that there will often be found a greater or less number of imperfect and incompletely formed spicules, some with only slight defects in form, regularity, etc., others so imperfect that their nature is doubtful, and they may be regarded as merely shapeless calcareous deposits. In a majority of the colonies, however, such imperfect spicules are few, or wanting almost entirely, and the spicules under magnification present a picture of striking uniformity and regularity in shape and size.

Such spicules as shown in Fig. 18 may be regarded as the typical shape for this species. They have moderately numerous, tapering, conical points or rays, beautifully regular in form and arrangement, but the stoutness of the cones in proportion to their height, the number of points or rays, and the bulk of the solid central mass formed by their bases (or from which they may be regarded as projections) vary in different colonies, though often fairly constant within any single colony. Such spicules are usually from .030 to .045 mm. in diameter.

From this typical form modifications may take place in several directions, as shown in the illustrations, resulting in extreme cases in spicules of quite different appearance. These modifications are apparently often a manifestation of a certain degree of deficiency in the spicule-forming function of the colony or, as suggested by Michaelsen (1919a, p. 6), of arrested development of the spicules before they have attained their perfect form.

The chief modifications from the typical form of spicules consist in (1) a blunted or more or less broken condition of the points (Figs. 17, 23, 24) which, when carried to an extreme, results in considerable shortening of the latter and an approach to a knobbed spherical form for the spicule as a whole (Figs. 17, 25); (2) a rounding out of the sides of the cones which may nevertheless remain sharp (Figs. 20, 21); (3) an approach to a cylindrical form in the points or rays, the tips being blunted or rounded (Fig. 22); and (4) in the points or rays becoming weak, slender and needle-like, resulting in a burr-like spicule (Fig. 23). In this last modification the spicules often become much reduced in size. All these various modifications occur in varying degrees and may be accompanied by increase or decrease in the number of rays or components of the spicules, so that a great variety of minor modifications result.

Except in the form treated below as a separate species (*D. fusi-ferum*) and in one other case I have been unable to connect variation in the spicules with geographical distribution. Colonies with typical or nearly typical spicules are the most numerous; those exhibiting extremes of variation of any kind are less often met with. The modifica-

tions shown in Fig. 23 are, however, quite frequent; when colonies grow under conditions unfavorable for spicule formation, the production of such burr-like spicules (usually small in size and reduced in numbers) seems to be the most common result.

In a previous article (1902) I gave names to several variations of this species that were collected at Bermuda (vars. *bermudense*, *pageti*, *hamiltoni*, *harringtonense*, *acutilobatum* and *somersi*), but at the present time I cannot regard these as representing true races or subspecies. Herdman's (1886) var. *asperum*—the name *asperum* is antedated by *D. asperum* (Milne-Edwards), 1841—may likewise merely represent an individual variation. *Didemnum lutarium* Van Name, 1910, on the other hand, may have some claims to validity as a subspecies (see below).

In completing this description of the general character of the colony, it should be mentioned that there are occasional colonies, apparently of this species, which for some unexplained reason develop very few spicules in the test, so that the colony remains soft, flexible, semitransparent, and (in the preserved material) of a yellowish or grayish color. The few spicules present are generally in the upper parts of the colonies (sometimes chiefly about the branchial apertures of the zooids) and are of small size and usually of the forms shown in Fig. 23. Such colonies may attain a large size and appear normal in all other respects except in the scarcity and poor development of the spicules, though this deficiency gives them a very different superficial appearance. I have seen such colonies from widely separated localities (Florida, Porto Rico, and South Carolina).

There are also colonies containing large accumulations of dark-colored faecal pellets in the cloacal canals and cavities and imbedded in the solid test substance. I quite agree with Michaelsen's view (1919a, p. 11) that this is merely the result of some abnormal or pathological condition, the water currents being insufficiently strong to carry off this waste material. Its presence in large quantities may greatly alter the appearance of the colonies and make it difficult to realize that they belong to the same species as normal examples, and Sollas, 1903, even went so far as to found a genus (*Hypurgon*) on a colony of one of the common species of *Didemnum* exhibiting the above conditions. (See Michaelsen 1919a, p. 11.) That some of the faecal pellets occur imbedded in the test itself requires no difficult explanation. In the course of the growth and development of the colony certain branches of the cloacal canals cease to be functional because of the death and absorption of the zooids discharging into them. The growth of the test substance closes these

functionless branches and gradually fills their cavities, leaving the deposits of faecal pellets they contained entirely surrounded by test substance.

When considerably expanded, the zooids may measure 1.6 mm. in total length, even in preserved material, but in most alcoholic specimens they will be found strongly contracted and often not more than 1 or 1.1 mm. long. They have six lobes to the branchial tube; these lobes vary greatly in length and form in different colonies. A tapering muscular process, often of considerable length, extends out into the test from the constricted middle part of the zooid; its development is very variable in different colonies, though often quite constant within the same colony. Atrial orifice round, without a languet. Its border is usually almost flush with the dorsal surface of the thorax; even if slightly raised it is not produced sufficiently to form a tube.

In adult zooids there are generally sixteen tentacles representing three orders (4+4+8), but one or two of the large ones may exceed the others in size and the small tentacles do not appear to be always developed.

Dorsal languets borne on the transverse vessels of the left side of the branchial sac a little removed from the median dorsal vessel.

Stigmata in four rows; twelve on each side was the maximum number demonstrated in a single row; in many cases the number in a row does not appear to be so large, about ten in the anterior rows and as few as eight in the posterior row.

Stomach rounded; ascending part of the intestine surrounded by a branching glandular organ composed of from five to ten thin-walled tubules which unite to form a duct opening into the proximal part of the intestine just beyond the pylorus. One or more valvular constrictions may be present in the intestinal loop; their presence does not seem to be a constant character.

Testis sometimes cleft into two more or less completely or almost completely separated lobes or distinct glands, but oftener it is undivided. I have never observed it cleft into three lobes or glands. The sperm duct usually makes six or eight spiral turns about the testis. Ovary consisting of a few eggs situated in the region between the stomach and testis.

This species ranges on the American coast from the Isles of Shoals off the coast of New Hampshire (though it is local or rare north of Cape Cod) to Bahia, Brazil (Herdman, 1886), including Bermuda, and is in many parts of the West Indian region the commonest of the littoral and shallow-water ascidians, and the species that in a miscellaneous collection will usually be most numerous represented. Almost all the speci-

mens in the collections studied are from shallow water (low water to 28 fathoms), but the National Museum collection contains a few specimens from deeper water, 98 to 201 fathoms (see below) that appear to belong here.

It is abundant at Bermuda, on both coasts of Florida and in the comparatively shallow water of the eastern part of the Gulf of Mexico, and at Porto Rico (south coast). Other localities are the Bahamas; St. Thomas (on piles); off Cape San Antonio, Cuba; Montego Bay, Jamaica; Colon, Panama. Specimens from along the coast of the United States between Florida and Long Island, N. Y., are few. The National Museum collection, however, contains colonies from Winyah Bay, South Carolina, and from Stations 2617, Steamer Albatross (33° 37' 30" N., 77° 36' 30" W., 14 fathoms) and 2619 (33° 38' N.; 77° 36' W., 15 fathoms); also from Hampton Roads, Virginia. On the coasts of Long Island, N. Y. and southern New England it again becomes common; the specimens from this region appear to represent a slightly distinguished northern race or subspecies described originally as a species, *D. lutarium* Van Name, 1910. This race was for a long time confused by Verrill and others with *D. (Tetradidemnum) albidum* (Verrill), 1871, a totally different arctic and subarctic species whose range overlaps that of the present one on the New England coast. The New England subspecies or race (*lutarium*) is characterized by rather small spicules (in many colonies only .02 to .025 mm. or less in diameter), with rather short, though well-formed, conical points, rounded off at the extreme tip (Fig. 19); rather small zooids; and, in contrast to the great variability exhibited by Florida, Bermuda and West Indian specimens, by a considerable degree of constancy in the above characters. On the coasts of the Southern States it appears to grade into the typical form.

Specimens of this species from deeper water were collected by the Steamer Albatross and Fish Hawk at the following Stations: Station 2387, 29° 24' N., 88° 04' W., 32 fathoms, sand, gravel, and broken shells; Station 2147, 9° 32' 20" N., 79° 54' 45" W., 34 fathoms, coral; Station 7511, Gulf Stream off Cape Florida, 45 fathoms, rocky; Station 2159, 23° 10' 39" N., 82° 20' 08" W., 98 fathoms, coral; Station 2168, 23° 10' 36" N., 82° 20' 20" W., 122 fathoms, coral; Station 2323, 23° 10' 51" N., 82° 19' 03" W., 173 fathoms, coral; Station 2264, 37° 07' 50" N., 74° 34' 20" W., 167 fathoms, gray sand; Station 2167, 23° 10' 40" N., 82° 20' 30" W., 201 fathoms, coral. Most of these deeper stations are so located that the bottom temperature cannot have been very low.

It grows on any kind of bottom affording objects to attach itself to, and is often found on other ascidians. Two colonies (apparently of this species, though containing very few and small spicules) covered the backs of crabs, probably *Dromidia antillensis*, found on piles of the railroad wharf at Montego Bay, Jamaica.

Savigny's type of this species was from the Red Sea. Material from that region has recently been studied and described in detail by Hartmeyer, 1916, p. 419, and Michaelsen, 1919a, p. 18, and there seems to be no sufficient reason for maintaining the American form distinct from it. I believe that the species is very widely distributed in the Indian Ocean and Malay region, and that a number of the supposed species that have been described from those parts of the world must be united with it. The Philippine form *D. grande* (Herdman), 1886, (see also Van Name, 1918) is among those probably synonymous. Michaelsen (1919a, p. 18) would also unite specimens from the region of the Straits of Magellan with Savigny's form. If no distinguishing character can be discovered, the justification for this course must be admitted, although the occurrence of a more or less decidedly tropical form in a region of such cold water is hardly what would be expected. I must, however, differ most decidedly with him in his proposal (*loc. cit.*, p. 23) to separate the Bermuda *Didemnum*s from the other tropical American ones and unite them with *D. studeri* Hartmeyer, 1911 (type from Kerguelen Id.), apparently merely because they often have the testis divided into two parts. That is an individual peculiarity which occurs also in some West Indian and New England specimens and does not appear to be of importance. But, even if it were so, the fact that *D. studeri* commonly, if not normally, has a three-parted testis, a condition I have never observed in the many West Indian and Bermuda colonies I have examined, would seem to exclude identity with that antarctic and sub-antarctic species, aside from the improbability of it on account of climatic reasons.

***Didemnum fusiferum*, new species**

Figure 26

In dealing with the species just described, instances of colonies with poorly developed spicules were noted. In such specimens the spicules are generally below the normal both in respect to number and size and in the development of their rays or points, which may deviate from the normal conical form in either of two principal ways, by being irregularly blunted and shortened, or by becoming slender and less regular (sometimes needle-like) and very numerous, resulting in a burr-like, rather

than a stellate, spicule. Either of those modifications, if carried to an extreme, results in a nearly spherical spicule whose true character is visible only by considerable magnification.

The National Museum collection, however, contains some specimens from the Gulf of Mexico having spicules of a totally different character, a considerable proportion of them being fusiform, that is, composed of two cones placed base to base. Such may be regarded as two-rayed spicules. In the same colonies are other spicules composed of four, six, eight, or more such conical points; when these points are sufficiently numerous the spicule approaches the usual stellate form.

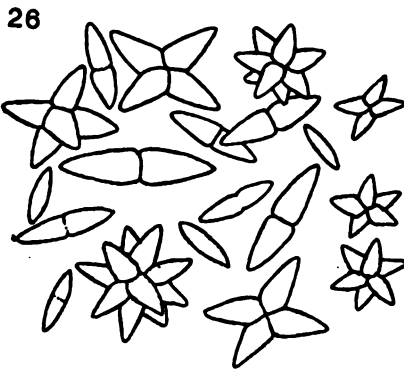


Fig. 26. *Didemnum fusiferum*, new species
Spicules, $\times 460$.

I have been at a loss as to how to deal with these specimens. They may represent merely another of the endless variations of *D. candidum*, but, if so, the deviation of the spicules from the usual type is not of the nature either of arrested development or degeneration, since the points, even when only two or four in number, are commonly perfectly formed. The occasional occurrence of similar spicules in *Didemnum japonicum* (Herdman), 1886 (p. 302, Pl. xxxiv, figs. 1-7), is recorded, though most of the spicules in that form are of the usual stellate type.

Colony of the incrusting type, in some parts quite thin (3 mm. or less) but sometimes becoming thick and massive, especially when growing upon irregularly shaped objects. Several large colonies from off Cedar Keys, Florida, growing on branching gorgonians, surround their branches, and where the latter are near together envelop and bind together two or more of them in the test, which becomes very thick and massive (sometimes over 30 mm. thick, where there are zooids on all aspects). One of these irregularly lobed and extended colonies measures

not less than 220 mm. by 125 mm. in its greatest dimensions. The free edges are for the most part thick and rounded.

Test in alcohol of the usual yellowish color, not pigmented, translucent; the more opaque but light-colored zooids are visible through it and are arranged along complex branching and anastomosing common cloacal canals, which in the preserved (but probably not in fresh) material are often rendered still more conspicuous by furrows on the surface. The apertures are not conspicuous in any of these specimens.

Spicules generally too few to have much effect on the transparency or consistency of the test; they are irregularly distributed, chiefly in the upper parts of the colonies, and are entirely wanting in most parts. Their peculiar forms (Fig. 26) have been already described; in size they present nothing unusual, the larger ones averaging only from .02 to .03 mm. in diameter from point to point. Among the perfectly formed spicules are also imperfectly or incompletely formed ones, and also crystalline and irregular deposits of calcareous material, which may much exceed the true spicules in number and bulk.

Zooids fairly large, 1.25 mm. or more long when only moderately extended. They agree too closely with those of *D. candidum* in their characters to require separate description or illustration. The muscular process extending into the test is long and well developed; the testis, as in *D. candidum*, may be either single or distinctly cleft into two divisions.

The specimens are all from off the west coast of Florida. The type and also several other colonies (or perhaps fragments of the same colony) are from Station 7147, Steamer Fish Hawk (29° 52' 10" N., 83° 51' 47" W., 3 fathoms, sand and coral); some large colonies (see above) were collected in the vicinity of Cedar Keys, Florida, by the Steamer Bache, in February 1887, probably also in water several fathoms deep.

Subgenus **POLYSYNCRATON** (Nott), 1891

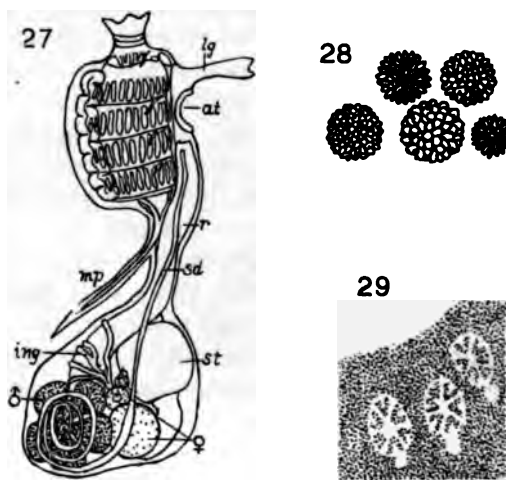
Differs from the typical subgenus of *Didemnum* in having the testis divided into several entirely separate glands, disposed in a circular group, about which the sperm duct coils. The typical species (including the West Indian form) have an atrial languet.

Didemnum (Polysyncraton) amethysteum (Van Name), 1902

Figures 27-29

1902. *Polysyncraton amethysteum* Van Name, Trans. Conn. Acad. Sci., XI, p. 366, Pl. LIV, figs. 62, 64-67; Pl. LVIII, fig. 102.
1909-11. *Polysyncraton amethysteum* Hartmeyer, Bronn's 'Tier-reich,' III, suppl., pp. 1452.
1912. *Polysyncraton amethysteum* Hartmeyer, 'Deutsch. Tiefsee-Exp.,' XVI, p. 325.

The colonies in this species are of the flat, incrusting type; the upper surface is nearly smooth and even, the thickness of the colony is about 3 mm., and the greatest diameter rarely over 25 or 30 mm. In spite of their small size, they are during life of striking appearance. The test is transparent and of a handsome purple or rose-purple tint which fades to yellow on preservation. The color is due to pigment in the test cells. The zooids during life are bright red. The upper surface-layer of the colony contains a layer of small white burr-like or almost spherical spicules, but small oval areas about the branchial apertures of the



Figs. 27-29. *Didemnum (Polysyncraton) amethysteum* (Van Name), 1902
 Fig. 27. Left side of zooid, $\times 40$. Fig. 28. Spicules (all from same colony), $\times 460$. Fig. 29. Part of surface of colony showing distribution of spicules in superficial layer of test, $\times 11$.

zooids and a large central area on the upper surface of the colony surrounding the common cloacal aperture (there appears to be usually but one) are without spicules, except that in the small areas about the branchial orifices there are six small V-shaped groups of them corresponding to the intervals between the six lobes of the branchial tubes. The deep purple of the exposed areas of the test, with the contained brightly colored zooids, often shows in a strong contrast to the pure white of the spicule-covered portion. The layer of test containing the spicules may readily be stripped off. Spicules always small, .015 or .02 mm. in diameter or even less, with short and often more or less blunted rays, so numerous that the spicule appears nearly spherical except under high magnification.

Zooids about 1.5 mm. long when well expanded. Body strongly constricted between thorax and abdomen; a tapering muscular process extends ventrally and posteriorly out into the test from the constricted part of the body. Branchial aperture six-lobed, atrial plain, with a languet at its anterior border. This languet is, in well-expanded zooids, fairly long and wider toward the end, where it is slightly forked. In strongly contracted individuals it is merely a small tongue-like projection.

Well-developed longitudinal muscle bands present on the thorax.

Tentacles at least eight in number, additional smaller ones are probably present.

The dorsal languets apparently arise from the transverse vessels of the left side, but the sac was too much contracted in the specimens studied to determine this satisfactorily.

Stigmata in four rows; apparently about a dozen in a row on each side.

Male reproductive organs consisting of a group of about five or six radially disposed, pear-shaped testes, whose narrow ends are connected with the origin of the common sperm duct by very short individual ducts. The common sperm duct makes about five loose spiral turns about the whole group before accompanying the distal branch of the intestine. Ovary between the testis and stomach. Eggs very large when fully grown.

This species is moderately common at Bermuda on stones along the shore and in other shallow situations. I have also found it growing on calcareous algæ on the banks near Soldier's Key, Biscayne Bay, Florida.

The type (from Bermuda) is in the Yale University collection.

LEPTOCLINUM Milne-Edwards, 1841

[= *Diplosoma* MacDonald, 1859. Proposed *nomen conservandum*,
Diplosoma]

In this genus there are four rows of stigmata, the testis is divided into two separate glands, and the sperm duct is not spirally coiled. No atrial languet or atrial tube is developed and the test is without spicules. Usually the common cloacal cavities are greatly developed.

Leptoclinum macdonaldi (Herdman), 1886

[*Diplosoma macdonaldi* under proposed system of *nomina conservanda*]

Figure 30

1886. *Diplosoma macdonaldi* Herdman, 'Rept. Voy. Challenger, Zool., XIV,' p. 315, Pl. xlii, figs. 1-4.

1891. *Diplosoma macdonaldi* Herdman, Journ. Linn. Soc. London, Zool., XXIII, p. 633.

1898. *Diplosoma macdonaldi* Gottschaldt, Abh. Senckenb. Gesell., XXIV, p. 657.
 1902. *Diplosoma macdonaldi* + *D. lacteum* + *D. atropunctatum* Van Name, Trans. Conn. Acad. Sci., XI, pp. 368-370, Pl. LIII, figs. 56, 59, 60; Pl. LVIII, fig. 103; Pl. LX, fig. 124; Pl. LXII, fig. 137.
 1909-11. *Leptoclinum macdonaldi* + *L. lacteum* + *L. atropunctatum* Hartmeyer, Bronn's 'Tier-reich,' III, suppl., pp. 1454, 1455, 1633, 1634, 1645.
 1918. *Leptoclinum macdonaldi* Van Name, Bull. U. S. Nat. Mus., No. 109, I, p. 159, fig. 109.
 1920. *Diplosoma macdonaldi* + *D. lacteum* + *D. atropunctatum* Michaelsen, Jahrb. Wiss. Anst., Hamburg, XXXVII, suppl., p. 71.

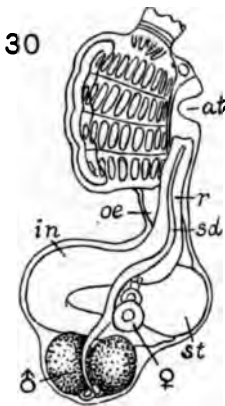


Fig. 30. *Leptoclinum macdonaldi* (Herdman), 1886

Leftside of zooid, $\times 48$.

Colony thin and incrusting, rarely much over 2 mm. thick, but sometimes 50 mm. or more across. (One specimen surrounds a blade of turtle grass for a length of 138 mm.) Test transparent and colorless in life, sometimes suffused with milky white which commonly disappears on preservation. The zooids are clearly visible through the test and often quite conspicuous as small, irregularly distributed, blackish objects, since they usually have more or less black pigment in the mantle cells about the branchial tube and on the surface of the abdomen. Their tissues are otherwise light colored, except that the stomach and part of the intestinal loop are yellow or orange during life, fading out in preservation.

Common cloacal cavities very extensive, though developed to a varying degree in different colonies; in extreme cases the entire interior of the colony may be hollow, except for columns or trabeculae of test substance in which the zooids are imbedded. Large and conspicuous, pale yellowish, oval cells are often present in the test substance; they are perhaps symbiotic vegetable cells.

Zooids very small; their apparent length is further diminished by the fact that the axis of the abdomen is usually bent at right angles to that of the thorax, so that they often average only .8 or .9 mm. long in the preserved colonies, but when moderately expanded and straightened out they may measure 1.5 or 1.6 mm. in total length. As seen from the surface of the colony, the branchial apertures appear round or oval, without lobes, but the usual six lobes are slightly developed on the branchial tube and are often visible within the circular exterior orifice. No atrial tube or atrial languet; the atrial opening is large and plain-

edged; no muscular process from the constricted middle part of the body, but one or two vascular processes may extend from this part of the body. Mantle musculature insignificant.

Tentacles twelve, of three sizes, regularly arranged.

Dorsal languets apparently long and narrow; very difficult to demonstrate.

Four rows of stigmata with about ten in a row on each side.

Stomach rounded, smooth-walled, intestine of rather large diameter. I have not succeeded in demonstrating in this genus the glandular tubules clasping the intestine, which are so conspicuous in *Didemnum* and *Trididemnum*.

Testis consisting of two large oval glands lying beside the intestinal loop (the lateral bending of this loop brings them, however, to the extreme posterior end of the body). They are connected with the proximal end of the common sperm duct by short individual ducts. The common sperm duct does not coil about the testis. Female reproductive organs represented by one or more eggs beside the intestinal loop.

The additional material now available comprises specimens intermediate in character between this species, *L. lacteum* and *L. atropunctatum*, and in the present paper all three are united under Herdman's name *macdonaldi*.

This is a common and widely distributed animal, ranging from Bermuda and South Carolina (Blackfish Banks off Charleston, specimen in National Museum) to Bahia, Brazil, the locality of Herdman's type. I have collected it at Bermuda in shallow water and the American Museum expedition obtained it in Guanica Harbor and at several points off the southern coast of Porto Rico in depths from 6 to 8 fathoms. In the National Museum collection it is also represented by many specimens dredged off the west coast of Florida from Cedar Keys to the vicinity of Key West, in depths down to 27 fathoms, and by specimens from Charlotte Harbor, Florida; Jamaica, W. I.; and St. Thomas, W. I., (shore). Hartmeyer (1909-1911, p. 1629) reports a *Leptoclinum*, very probably this species, from Tortugas, Florida, and West Indian localities. It appears, moreover, to be much more widely distributed, since what seems to be the same species occurs in the Malay Region (Ternate and the Philippines); see Gottschaldt, 1898, and Van Name, 1918.

It appears to grow more commonly on corals, gorgonians, sponges, and other ascidians in water at least a few feet deep than near low-water mark, perhaps because its delicate structure is not adapted to withstanding either exposure to the air or to strong waves.

Lissoclinum Verrill, 1871[= *Diplosomoides* Herdman, 1886]

Similar to *Leptoclinum* in general characters, but with stellate calcareous spicules in the test. Four rows of stigmata, testis partially or completely divided into two or more glands or lobes; sperm duct not coiled, atrial orifice with a languet.

Lissoclinum fragile (Van Name), 1902

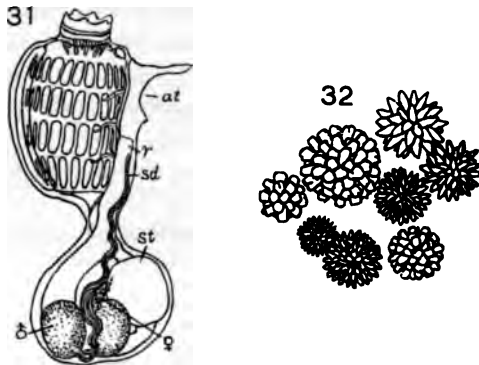
Figures 31 and 32

1902. *Diplosomoides fragile* Van Name, Trans. Conn. Acad. Sci., XI, p. 370, Pl. LIII, figs. 57, 58; Pl. LXI, fig. 126.

1909. *Diplosomoides molle* (part) Sluiter, 'Siboga-Exped.,' LVIb, p. 85.

1909-1911. *Diplosomoides fragile* Hartmeyer, Bronn's 'Tier-reich,' III, suppl., pp. 1546, 1633.

1912. *Diplosomoides fragile* Van Name, Proc. Boston Soc. Nat. Hist., XXXIV, p. 389.



Figs. 31 and 32. *Lissoclinum fragile* (Van Name), 1902

Fig. 31. Left side of zooid, branchial sac well expanded. $\times 36$. Fig. 32. Spicules (all from same colony), $\times 460$.

This animal forms very thin, flat, incrusting colonies, often of considerable extent (60 mm. to 80 mm. across), but only 2 to 3 mm. thick. Living specimens collected at Bermuda were easily recognizable by two characters; first, their snowy whiteness without the least tinge of yellowish (though preserved specimens become somewhat yellowish) and, second, by their very fragile character. The test breaks or tears at the slightest touch, and the colony cannot readily be removed entire from the surface on which it grows. The white color is due to the spicules that densely crowd the test and conceal the zooids, which are yellow or orange during life. The spicules are minute (usually not more than .02 to .023 mm. in diameter) and stellate or burr-like in form, built up of

very numerous rays which may end in sharp points, but are more often truncated or broken at the tips (see Fig. 32). The rays or points are so short and numerous that under low magnification the spicules appear nearly spherical. The fragile character of the colony is in part due to the brittleness of the test, caused by the great abundance of spicules, but still more to the very extensive development of the common cloacal cavities which commonly reduce the test substance to two thin layers forming the upper and lower surface of the colony respectively, and to small masses or trabeculæ connecting these two layers. In these trabeculæ the bodies of the zooids are contained. The colony thus consists of extensive systems, whose cloacal cavities are more or less confluent. The apertures of the zooids are usually quite conspicuous on the surface of the colony, which is fairly smooth though not glossy during life, but becomes much wrinkled through the collapse of the common cloacal cavities in preserved specimens.

Zooids about 1.5 long when fairly well expanded. They have the branchial aperture six-lobed; the atrial is provided with a languet. No muscular process extending out into the test is developed.

Mantle musculature and muscles of the branchial sac very weak.

Tentacles slender, of at least two sizes.

Dorsal languets difficult to demonstrate.

Branchial sac large, with four rows of large stigmata; probably about ten or eleven in a row on each side.

Intestinal loop small; stomach very thin-walled, so that it becomes folded in preservation, but it is probably round and smooth-walled during life.

Male reproductive organs consisting of two large oval testes beside the extreme posterior part of the intestinal loop. Their short individual ducts unite to form a stout common duct which accompanies the ascending or distal branch of the intestinal loop without making any spiral turns about the testes. The ovary, a small group of eggs, lies beside the common sperm duct a little from its origin.

This species was found common at Bermuda at a number of stations along the shore, growing on the under side of stones near low water. The only other locality is St. Thomas, W. I., where some good-sized colonies were collected by Mr. C. R. Shoemaker in 1915 (National Museum collection) growing on ascidians (*Phallusia hygomiana*), on piles, and elsewhere in shallow water ($\frac{1}{2}$ to $2\frac{1}{2}$ fathoms). Sluiter (1909) has expressed the belief that this species is not distinct from the Malayan species, *Diplosomoides molle* Herdman, 1886, originally described from the Aru

Islands, but his conjecture does not seem to be based on any actual comparison of material. That species is reported to form habitually dome-shaped colonies with a large common cloacal aperture at the summit and, considering the widely separated localities of the two species, the question should be left open for the present.

The atrial languet does not appear to be present in immature zooids and, even in fully adult ones, it is very easily torn off in dissecting out the zooid for examination. The original description and figure gave it as wanting. The demonstration of its presence appears to remove the reason for considering *Diplosomoides* Herdman, 1886, as a genus distinct from *Lissoclinum* Verrill, 1871.

ECHINOCLINUM Van Name, 1902

This genus is closely related to *Lissoclinum* and *Leptoclinum* and perhaps better regarded as a subgenus of the former, though at once distinguishable from it by the peculiar form and arrangement of the spicules described below, and it is hardly necessary to add that I most decidedly oppose Michaelsen's (1915, p. 481) proposal to remove it to the Clavelinidae or to regard it as in any way intermediate between that family and the present one, although the material available has unfortunately not proved favorable for a study of its budding.

The following is the only known species.

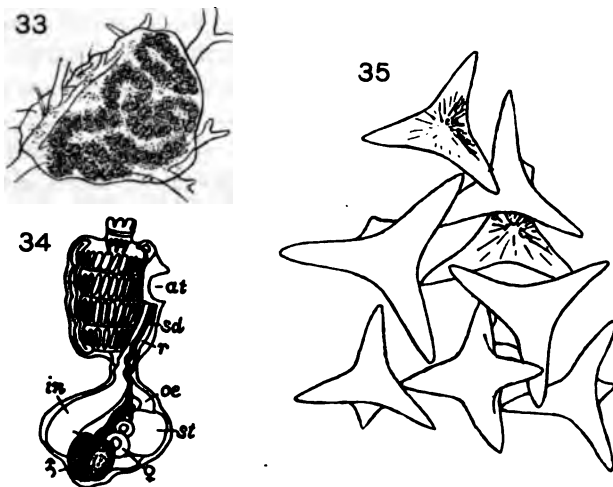
Echinoclinum verrilli Van Name, 1902

Figures 33-35

1902. *Echinoclinum verrilli* Van Name, Trans. Conn. Acad. Sci., XI, p. 372, Pl. I, figs. 23-25.
1907. *Echinoclinum verrilli* Seeliger, Bronn's 'Tier-reich,' III, suppl., p. 1236.
1908. *Echinoclinum verrilli* Hartmeyer, Zool. Annal., III, p. 44.
1909-11. *Echinoclinum verrilli* Hartmeyer, Bronn's 'Tier-reich,' III, suppl., pp. 1452, 1630, 1633.
1915. *Echinoclinum verrilli* Michaelsen, 'Beitr. Meeresfauna Westafrikas,' I, p. 481.

Colony of the flat incrusting type but usually rather thick, with the upper surface generally smooth but uneven. It attains a considerable size, one specimen from near Key West, Florida, measuring 125 mm. by 95 mm. across and averaging at least 5 or 6 mm. in thickness (at some points considerably more). Zooids arranged in systems often of considerable extent and complexity. In large specimens the zooids can often be seen to be in double rows, between which run the common cloacal canals; these branch and anastomose in a net-like manner, leaving in the meshes islands of completely inclosed areas of test, bordered by the rows

of zooids, but free from zooids in their central portions. In the preserved material these inclosed areas of solid test shrink less than the parts of the surface where the zooids and cloacal canals are situated, and often stand out as low, rounded elevations, separated by distinct furrows representing the ramifications of the systems. This may, however, be largely an artificial condition; at least it must be much less conspicuous in living, expanded material. Test colorless or somewhat yellowish and transparent in preserved specimens. No notes on its colors during life. Common cloacal cavities not extensive. Test tough externally, softer and



Figs. 33-35. *Echinoclinum verrilli* Van Name, 1902

Fig. 33. Colony (type) growing upon a branching seaweed, $\times 2$. Fig. 34. Left side of zooid, $\times 36$. Fig. 35. Spicules, $\times 230$.

more gelatinous within, except immediately about the zooids where most of the spicules are located. There it forms a tough membranous investment around each zooid from which it is very difficult to remove the latter, especially as the test adheres very strongly to the bodies of the zooids about the atrial aperture and at a point on each side of the thorax near its posterior end where there is a deep depression in the wall of the thorax that unquestionably represents the "Seitenorgan" of Michaelsen (see p. 313). The test, especially the above-mentioned tough layer, contains many large, yellowish, irregularly oval cells with refractive globules in the cytoplasm. The spicules are peculiar, having the form of tetrahedrons whose four apices are produced into somewhat elongated points. These spicules are mostly so placed about the bodies of the zooids

that they form a spiny capsule about them, one of their four points projecting radially outward. Similar spicules are also scattered in other parts of the test, sometimes in considerable abundance, especially in the superficial layer of the colony. The larger spicules measure up to about .10 to .14 mm. from point to point, but there are many smaller ones. Some of the specimens contain additional calcareous matter deposited in the test in irregular granular or semicrystalline form; in one specimen the spicules have acted as centers for the disposition of such material to an extent that conceals their original form.

Zooids small, often less than 1 mm. long in the strongly contracted preserved condition. Branchial aperture six-lobed, atrial a large plain-edged opening whose anterior margin may be a little produced, but hardly enough to be termed a languet. No muscular process extending out into the test was observed.

The tentacles and dorsal languets were visible with difficulty in the contracted specimens; there are at least two sizes or orders of tentacles.

Branchial sac with four rows of stigmata, probably nearly a dozen in a row on each side.

Stomach rounded and smooth-walled externally, though slightly ridged in a longitudinal direction internally.

The ovary, consisting of a small cluster of eggs, is situated beside the ascending part of the intestinal loop. The male organs consist of a rather large, rounded testis beside the posterior or transverse part of the intestinal loop. The testis is partially divided by a deep groove extending across its outer aspect. The large, stout sperm duct arises from the posterior border of the gland and lies in this groove; it then extends and accompanies the intestine to near its end. It is not spirally coiled.

This species was originally described from three small specimens collected at Bermuda in 1898 by Professor A. E. Verrill. Hartmeyer (1909-1911) reported it from Tortugas, Florida. The National Museum collection contains a number of colonies, some of them of considerable size, all dredged in the vicinity of the Florida Keys in three to eleven fathoms except one (also from southern Florida) which is attached to a blade of turtle grass and hence evidently came from very shallow water. One of the specimens covers the back of a small maioid crab, which it much exceeds in size.

Polycitoridæ Hartmeyer, 1915

[= Polycitoridæ + Clavelinidæ *auct. plur.*]

Compound ascidians having the body consisting of two parts (thorax and abdomen) joined by a constricted part or neck usually rather long. The buds form on vascular processes or stolons (often of considerable length) arising from the posterior

end of the abdomen of the parent. Dorsal lamina represented by separate languets. Reproductive organs in the abdomen (or in a diverticulum of it) on or near the loop formed by the intestine.

POLYCITOR Renier, 1804

Genus including forms with many rows of stigmata, and a plicated stomach wall (constituting the subgenus *Polycitor*) and those with but three or four rows of stigmata and a globular stomach, always smooth-walled, which constitute the subgenus *Eudistoma*. To this latter group the species here included in the genus all belong.

Subgenus **EUDISTOMA** Caullery, 1908

See above, under *Polycitor*.

Polycitor (Eudistoma) olivaceus (Van Name), 1902

Figure 36

1902. *Distoma olivaceum* Van Name, Trans. Conn. Acad. Sci., XI, p. 344, Pl. XLVIII, fig. 9; Pl. LIX, fig. 113.

1909. *Distoma olivaceum* Caullery, Bull. Sci. France et Belgique, XLII, p. 43.

1909-1911. *Polycitor (Eudistoma) olivaceus* Hartmeyer, Bronn's 'Tier-reich,' III, suppl., p. 1432.

1915. *Polycitor olivaceus* Michaelsen, 'Beitr. Meeresfauna Westafrikas,' I, p. 66.

The usual form of the colony in this species is a group of numerous, small, somewhat flat-topped heads of circular outline, with fairly abrupt sides which contract toward the base into a rather thick peduncle. The several peduncles expand and unite into a basal mass by which the colony is attached. These heads are usually only 5 to 8 mm. across and 8 to 10 mm. high, or often much smaller, but many may be united into one colony. The color in life varies from olive-green or yellowish olive to olive-brown, often more or less blackish on the upper surface. The color holds fairly well in alcoholic material.

Upper portion of colony smooth and shiny, free from incrusting or imbedded sand; the basal parts and peduncles contain sand grains and are often covered with an outside layer or pellicle densely crowded with fine sand. This pellicle, however, usually ends abruptly at the top of the peduncle. Test gelatinous and semitransparent, in spite of its dark coloration which is in part due to pigment contained in the test cells.

Zooids rather elongate, often 3.5 to 4 mm. long in the considerably contracted preserved condition. They are light-colored, with the stomach and parts of the intestinal loop orange during life. The mantle, especially on the anterior part of the thorax, is dotted with blackish pigment, sometimes to a very conspicuous extent; in other cases there is very little such pigment. In many colonies the regions over the ganglion and anterior end of the endostyle are much more deeply pigmented than

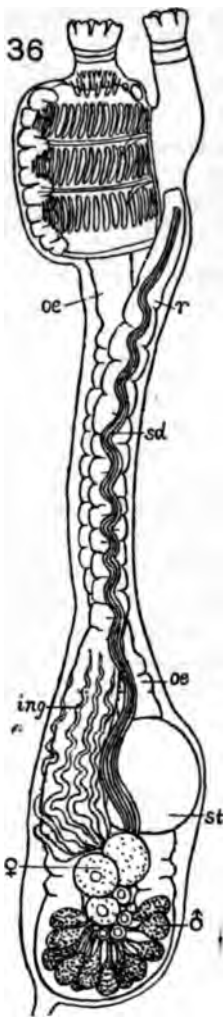


Fig. 36. *Polycitor* (*Eudistoma*) *olivaceus* (Van Name), 1902
Left side of zooid, $\times 32$.

any other part, so that these areas show from the outside of the colony as black dots on the otherwise light-colored zooids. Both apertures on tubes, the atrial usually the longer. Branchial aperture with six or seven, the atrial with six lobes.

Mantle musculature strong on the thorax, where it consists of many stout longitudinal bands and underlying transverse fibers. On the abdomen the long bands spread out and gradually become weak. They disappear near the posterior end of the body.

Tentacles of three sizes, apparently normally thirty-two in number, the small ones inserted a little nearer the branchial aperture than the larger ones.

Dorsal languets long and narrow.

The more extensive and better material now available shows that there are but three, instead of four, rows of stigmata in the branchial sac and that the original description and figure are wrong in that particular. The number of stigmata in a row is at least sixteen on each side; possibly several more.

Intestinal loop long and narrow; stomach large, globular and smooth-walled. Intestinal gland consisting of a number of thin-walled parallel tubules which at their posterior ends unite to form a common duct in the usual manner. They lie upon the external wall of the ascending part of the intestine near where it passes the stomach and, after running forward some distance along the intestine, each tubule tapers off and ends in a narrow point without branching. These tubules may, when the intestine is well extended, have a nearly straight course, but usually they are more or less sinuous and probably remain so even

during the maximum extension of the intestine that normally occurs.

Reproductive organs beside the intestinal loop (more or less on the left side of the body according to the amount the intestine is twisted). Testes small, oval or pear-shaped, usually eight to twelve in number

the specimens studied. They communicate with the origin of the large, thick-walled common sperm duct which accompanies the distal branch of the intestine by small delicate individual ducts. Ovary situated beside the testes.

This species is common and widely distributed in shallow water, growing especially on mangrove roots and on corals, etc., at or near low-water mark. Bermuda is the type locality (type in Yale University collection); it is represented in the collection of the American Museum by specimens from Andros Island, Bahamas; Porto Rico (mangrove roots in Guanica Harbor); Florida (Biscayne Bay on banks near Soldier's Key, and from the west shore of Plantation Key); and Cuba (Cayo Christo near Isabella on the north coast, 3 to 4 feet). In the National Museum collection there are specimens from several points on or near the west coast of Florida (depth given in one case only, Marco, Florida, 1 to 2 fathoms) and from St. Thomas, W. I. (shore).

There are also in this collection several colonies from Cedar Keys, Florida, and from Station 8269, Steamer Fish Hawk (Wingate Bay, South Carolina, 5 fathoms) that appear to belong to this species, but have the entire heads, which are narrow but of the usual height, very densely incrustated with sand. Sand also occurs to a greater or less extent in the interior of the test.

***Polycitor (Eudistoma) olivaceus form obscuratus* (Van Name), 1902**

1902. *Distoma obscuratum* Van Name, Trans. Conn. Acad. Sci., XI, p. 343. Pl. XLVII, fig. 11; Pl. LVIII, figs. 105, 106.

1909. *Distoma obscuratum* Caullery, Bull. Sci. France et Belgique, XLII, p. 43.

1909-1911. *Polycitor (Eudistoma) obscuratus* Hartmeyer, Bronn's 'Tier-reich,' III, suppl., pp. 1432, 1633.

The status of this species must be regarded as so doubtful, and its relationship to *P. olivaceus* so close, that it seems best to treat it as a form of the latter; possibly the colonies are merely abnormally shaped and colored examples of that species, yet they are certainly of very different appearance. It was described on the basis of two specimens in the Yale University Museum collected on corals in rather shallow water in Castle Harbor, Bermuda. They are of flattened, incrusting form, 20 to 30 mm. across and 3 to 4 mm. in thickness, with rounded edges. Test firm, with a smooth glossy surface free from adherent matter; common cloacal apertures appear to be present. Color uniform black (with a greenish tinge while alive) due to numerous pigment cells in the test and on the mantle of the zooids, where they are so abundant that the entire thorax is black.

In size and characters the zooids resemble those of the typical *P. olivaceus*. The tubules of the gland surrounding the intestine are exceedingly crooked, and somewhat swollen in their proximal portion, but a careful examination discloses that their distal parts ascend upon the wall of the intestine and taper off as usual in *P. olivaceus*, and that the original figure does not show this character correctly.

The National Museum collection contains two small flattened black colonies that also appear to be of this form; their test contains some sand grains. These specimens are from Drift Bay, Water Island (in the former Danish West Indies), and Tortugas, Florida, respectively.

***Polycitor (Eudistoma) convexus* (Van Name), 1902**

1902. *Distoma convexum* Van Name, Trans. Conn. Acad. Sci., XI, p. 342, Pl. xlix, fig. 16; Pl. LVIII, fig. 104; Pl. LIX, fig. 118.
 1909. *Distoma convexum* Caullery, Bull. Sci. France et Belgique, XLII, p. 43.
 1909–1911. *Polycitor (Eudistoma) convexus* Hartmeyer, Bronn's 'Tier-reich,' III, suppl., pp. 1431, 1633.
 1911. *Polycitor (Eudistoma) mayeri* Hartmeyer, Pub. No. 132, Carnegie Ins. Washington, p. 91, Pl. 1.
 1915. *Polycitor convexus* Michaelsen, 'Beitr. Meeresfauna Westafrikas,' I, p. 466.

Closely related to *P. olivaceus*, above described, but having a different habit of growth. The colony is larger and much more massive, usually forming an irregularly rounded or elliptical mass; in other cases it is broad and thick, and attached by most of the lower surface. Sometimes it may be capitate or consist of several heads united at their bases, but these are few and large; the colony does not break up into a multitude of small heads, as *P. olivaceus* commonly does.

It is also differently colored, being pale yellowish or brownish, often with a reddish or violet tint during life or even in preservation, instead of the greenish, olive, or blackish color of that species. The test in well-preserved material is translucent, so that the zooids may be more or less distinctly seen, and of fairly firm, often slightly cartilaginous, consistency. The basal parts of the test may contain, or be incrustated, with sand and shell fragments. Sand may be present to some extent in the interior of it, but in most specimens not in any great quantity, and the upper surface is smooth and glossy. In parts of some colonies an arrangement of the zooids in small circular or oval systems grouped about a small common cloacal cavity, with a rather large, rounded aperture, can be clearly demonstrated. In other specimens, or in other parts of the colonies, there is no apparent regularity in the distribution of the zooids. Most of the colonies are of rather small size, not over 20 to 30 mm. in diameter

and, if of the sessile type, not over 15 to 20 mm. high; if of the capitate type, proportionately higher. But very much larger colonies occur; the largest ones are generally of irregular outline and often divided by clefts into several lobes or heads. The National Museum contains large ones from the southern and western Florida coasts (55 mm. by 42 mm. across and 28 mm. high, also a crest-like colony 65 mm. high and 108 mm. by 40 mm. in its other maximum diameters, and another irregularly lobed one 115 mm. in greatest diameter and 60 mm. high), while one from Andros Island, Bahamas, in the American Museum collection surrounds a mangrove root for a length of 75 mm. The free edges and lobes of such colonies are thick, and rounded. The largest colony of all that I have seen is a dome-shaped mass about 170 mm. by 110 mm. in diameter and 75 mm. in greatest height.

The zooids resemble those of *P. olivaceus*, except that they are a little larger and stouter, ordinarily 4 to 6 mm. long in the somewhat contracted condition in which they are found in preserved material, but doubtless nearly twice as long when fully expanded. The mantle is very muscular, with strong longitudinal bands and underlying transverse fibers. The longitudinal muscles extend down on the abdomen, but posterior to the thorax they spread out and unite into a thin, broad sheet on each side of the body.

Tentacles apparently normally thirty-two in number, of three orders (8+8+16) regularly arranged.

There are three rows of stigmata, not four as originally stated and figured. In one specimen eighteen or nineteen were present in the anterior rows on each side, and sixteen or seventeen in the last row. These numbers may perhaps be a little exceeded in other cases.

The stomach is rounded and smooth-walled; the gland surrounding the intestine consists of a number of more or less parallel tubules which vary from quite straight to very sinuous in different individuals, and may in some places, especially near the lower end, become more or less distended with their secretion. The main direction of their course is, however, parallel with that of the intestine, along which they ascend for some distance, becoming smaller and tapering off to an exceedingly small diameter at their upper ends.

Large and well-developed zooids may have as many as thirty or forty testes. In most characters, however, the zooids closely resemble those of the last-described species and, as in that form, they are often, if not normally, more or less spotted with dark pigment (usually brown in the preserved specimens), especially on the anterior part of the body.

The type specimen of this species, a rounded colony 24 mm. in diameter, attached by much of its lower surface, was collected at Bermuda, where it does not seem to be very common. Other localities are Andros Island, Bahamas (see above); Cayo Christo near Isabella, north shore of Cuba, 3 to 4 feet; and near Georgetown Light, Winyah Bay, South Carolina (large colony thrown up on beach). It is, however, along and off the west and southwest coasts of Florida that this species seems to occur in greatest abundance and to grow to the largest size. There it was obtained at a number of localities, mostly in depths of under 10 fathoms. Though sometimes found near low-water mark, it seems to inhabit more frequently water a few feet or several fathoms deep (deepest station: Station 2362, Steamer Albatross, 22° 08' 30" N., 86° 53' 30" W., 25 fathoms). This species generally grows attached to corals, shells, gorgonians, etc.; one colony appears to have grown on the back of a crab.

There can be little question that Hartmeyer's (1911) *P. mayeri* from Tortugas, Florida, is this species. His failure to identify it as such was doubtless due to the error in the number of rows of stigmata (given as four instead of three) in the original description and figure.

***Polycitor (Eudistoma) hepaticus*, new species**

Very closely allied to *P. convexus*, just described, and possibly representing merely a variation of that species, is a large and massive form which is found in the same region. Characteristic specimens of it present a very different appearance from *P. convexus*, as described in the foregoing pages; the colonies usually form large ovoid or ellipsoidal masses, commonly more or less flattened in one direction and generally attached by a rather small area on or near one of the narrower sides or by one end; the surface of the test is more or less uneven, and large colonies are often partly divided by narrow clefts into two or more large lobes, which may have one or more of their sides flattened and the borders sharp and angular as a result of pressure against each other. In such cases the form of the colony, the dark color, and the consistency of the rather soft test give it an appearance suggesting the liver of a vertebrate animal, except that the color (in preservation) instead of red is a pure, intense purple, caused by grains of purple pigment in the test cells. There are no notes of the color in life. In some specimens the purple pigment is much less in amount, the colonies having sometimes only a pale purple or violet shade—in extreme cases only a purplish buff color; this may, of course, be in part due to fading. Such lightly pigmented colonies approach *P.*

convexus in color and appearance; the test, however, in the present form appears to be rather softer and less cartilaginous, and the surface more wrinkled and less glossy; the test, when pulled apart, tears rather than breaks.

As above stated, the colonies become large and massive; the type colony is a fair example of one of the larger specimens. It is of flattened, oblong form, about 80 mm. by 45 mm. by 25 mm. in its diameters, and is apparently attached by a rather small area near, but not on, one edge. The test is of a uniform deep purple color, due to the abundant purple pigment cells; the tissues of the zooids are not pigmented. Consistency of test rather soft, the solid interior parts a little firmer; surface slightly wrinkled and exhibiting small, rounded, depressed areas indicating the small circular or elliptical systems in which the zooids are arranged. The center of each of these systems, which appear usually to comprise eight to ten or more zooids, is occupied by a small common ocellar cavity with a rounded or somewhat lobed aperture.

Zooids apparently exactly like those of *P. convexus*, except that they average a little smaller and less stout. The testes numbered fifteen to twenty in the individuals studied, some containing young larva in the ocellar cavity.

The type colony, above described, is one of several similar ones collected by the 'Albatross' at Jamaica, W. I., January 1-11, 1884. Three exactly similar smaller ones of an equally deep purple color were collected by the 'Albatross' at St. Thomas, January 16-22, 1884; these appear to have grown on crabs. In July 1915, Mr. C. R. Shoemaker, of the National Museum, obtained a number of other specimens at St. Thomas on piles near the town. These exactly resemble the 'Albatross' specimens found there thirty years previously, both in their color and other characters; one of them is the most massive and bulky colony of a compound ascidian that I have ever seen. It is a somewhat flattened mass with thick rounded edges, about 270 mm. by 240 mm. across and about 100 mm. high, attached by a small area of the lower surface and partially divided by a wide, deep cleft into two nearly equal lobes connected at the base. This colony has on one side an irregular lateral extension which, if straightened and stretched out, would make the diameter of the colony passing through it reach 450 mm. The Yale University collection also contains a good-sized, rather deep purple colony, as well as some paler ones, from Fort Macon, North Carolina, collected by Dr. H. C. Yarrow; and the National Museum has some poorly preserved ones labeled Merida, Yucatan.

There seems, therefore, to be no possibility that the remarkable color of these specimens can be due to artificial or accidental staining from other material with which they may have been preserved.

Paler purple or slightly purple colonies in the National Museum collection, some of them of considerable size, which appear to be of this species, were obtained at Gunston, Potomac River, Virginia, and at Cedar Keys and Charlotte Harbor on the west coast of Florida. Such specimens, on account of their close approach to *P. convexus* make the problem of dealing with this form a very perplexing one, yet it would appear unjustified to stretch the diagnosis of *P. convexus* to include such very diverse specimens as would be necessary if this form were to be included there, and it seems best to treat it provisionally as a new species. Its range, excepting that it is not known from Bermuda, is even more extensive than that recorded for *P. convexus*, extending from Chesapeake Bay to Yucatan, Jamaica, and St. Thomas, W. I., which seems to exclude regarding it as a geographical race or subspecies of *convexus*.

This species is also nearly allied to a form found in the Philippines which I have identified with Sluiter's (1909) *P. ianthinus* (see Van Name, 1918, p. 135).

***Polycitor (Eudistoma) clarus* (Van Name), 1902**

Figure 37

1902. *Distoma clarum* Van Name, Trans. Conn. Acad. Sci., XI, p. 345, Pl. XLVIII, fig. 10; Pl. LIX, fig. 117.
1909. *Distoma clarum* Caullery, Bull. Sci. France et Belgique, XLII, p. 43.
1909-1911. *Polycitor (Eudistoma) clarus* Hartmeyer, Bronn's 'Tier-reich,' III, suppl., pp. 1431, 1633.
1915. *Polycitor clarus* Michaelsen, 'Beitr. Meeresfauna Westafrikas,' I, p. 466.
1916. *Distoma clarum* Pratt, 'Manual Common Invert. Animals,' p. 669.

Colony a small, rounded or oval mass without a peduncle, attached by most of the under surface. Test transparent and colorless in preserved specimens, but slightly opalescent in life, with a grayish, pinkish, or sometimes a blue or green cast. Size of the largest colonies about 12 mm. across and 6 mm. or less in height. Zooids irregularly distributed, lying in preserved colonies at all angles to the surface, no systems discernible. The zooids are visible with perfect clearness through the test.

Zooids small, provided with very strong longitudinal muscle bands on the thorax and anterior part of the abdomen; these usually produce such violent contractions in preserved specimens that the natural size and form of the zooid is entirely changed and distorted. Both apertures on tubes; the branchial tube very stout, six or seven-

lobed; the atrial longer, six-lobed. In immature zooids, both tubes may be mere conical projections. Posterior end of the body produced into a vascular process which is often very large and thick. Length of the zooids when moderately extended 3 to 4 mm. or more, but in the strongly contracted and distorted condition in which they are found in preserved specimens, usually much less (2 mm. or under). During life the thorax of the zooids is white, the stomach and more or less of the intestinal loop yellow or orange. In preservation the zooids fade to yellow or flesh-color, and usually eventually turn dark colored (dark yellow or brown).

Tentacles rather few but of three sizes, the smallest ones appear to be inserted in a circle somewhat anterior to the larger ones.

Dorsal languets inserted on the transverse vessels of the left side of the sac a little way from the median dorsal vessel.

Branchial sac with three rows of stigmata, not four as given in the original description and figure. About fifteen or sixteen stigmata in a row on each side.

Intestinal loop fairly long when not contracted; stomach proportionately large, globular and smooth-walled, but in preserved specimens the wall is usually found irregularly folded in consequence of the contraction of the body.

Testes and ovaries beside the intestinal loop, the stout common sperm duct accompanying the intestine to near its end. Testes few, usually six or eight in number, pear-shaped. Eggs large; the embryos develop into tailed larvæ in the atrial cavity of the parent. Sometimes four or five large embryos or larvæ, together equaling in bulk their parent, are found in the dorsal region of the body of a single zooid, greatly distending that part of the body, though no distinct incubatory pouch is formed.

This is one of the most abundant ascidians at Bermuda, occurring attached to stones along the shore and on corals, etc., on the reefs, but I have not yet seen it from any other locality. The type is in the Yale University collection.

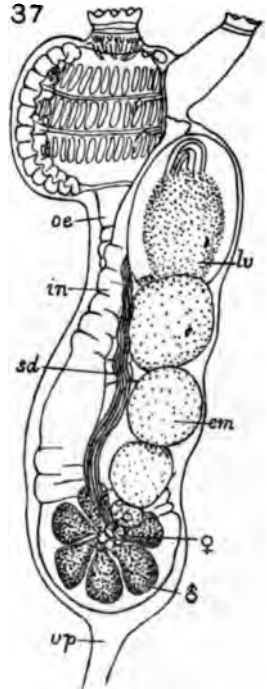


Fig. 37. *Polycitor* (*Eudistoma*) *clarus* (Van Name), 1902

Left side of zooid containing four developing embryos or larvæ, $\times 35$.

***Polycitor (Eudistoma) capsulatus* (Van Name), 1902**

1902. *Distoma capsulatum* Van Name, Trans. Conn. Acad. Sci., XI, p. 341, Pl. XLVI, fig. 2; Pl. LVIII, fig. 107.
1906. *Distoma capsulatum* Rennie and Wiseman, Proc. Zool. Soc. London, p. 908, Pl. LXV, fig. 21.
1909. *Distoma capsulatum* Caullery, Bull. Sci. France et Belgique, XLII, p. 43.
1909-1911. *Polycitor (Eudistoma) capsulatus* Hartmeyer, Bronn's 'Tier-reich,' III, suppl., pp. 1431, 1633.
1915. *Polycitor capsulatus* Michaelsen, 'Beitr. Meeresfauna Westafrikas,' I, p. 66.

This species was described from a few small colonies obtained at Bermuda in shallow water; only two of them were sufficiently large and well developed to afford any distinctive characters; the type, which measured 17 mm. by 11 mm. across and 5 to 7 mm. in thickness, and a somewhat smaller similar colony found with it. The latter has been at hand for re-examination in preparing this paper, but has not availed to clear up the uncertainty as to the validity and systematic position of this species, which must still be regarded as a doubtful one.

The colonies are small, irregularly convex masses of unsymmetrical outline, attached by the entire lower surface. Upper surface uneven, often slightly raised over the position of each zooid. Test colorless or nearly so, but rendered white, opaque, and rigid by numerous included sand-grains and shell-fragments, which are especially closely packed about the zooids so as to form a sort of capsule around them.

As far as the general character of the colonies is concerned, there would seem to be no great objection to regarding them as merely poorly developed and slightly abnormal colonies of *P. convexus*. The zooids are few and mostly much contracted. The few well-developed ones are rather large and suggest from their strong thoracic musculature (which at the posterior end of the thorax is gathered into a broad band passing down on each side of the abdomen) the zooids of the genus *Cystodytes*. The way in which the calcareous sand-grains in the test surround in capsule-like fashion the bodies of the zooids is also suggestive of that genus. Whether there are actually four rows of stigmata (which would further support its relationship to *Cystodytes*, since the West Indian *Polycitors* have but three) I was unable to determine on account of the condition of the zooids. A careful search, however, failed to reveal any of the characteristic disk-like spicules of *Cystodytes* in the test, or anything that could be certainly regarded as a fragment of such a spicule, and in their absence the specimens cannot be assigned to that genus.

A further peculiarity of the zooids is in the structure of the gland surrounding the intestine, which is demonstrable in several of the zooids.

The tubules are numerous and close together, clasping and entirely surrounding the ascending branch of the intestine for a short distance; they are somewhat distended and appear to end in enlarged bulbs. I could not find the slightest evidence of their ascending along the intestine and tapering off to narrow, pointed tips as in *Polycitor convexus*, although the conditions for demonstrating the structure appeared very favorable.

These peculiarities appear to stand in the way of identifying this form with any of the other species here described. The only other record for it, besides the original one from Bermuda, is that of Rennie and Wiseman, who somewhat doubtfully identify a small colony from the Cape Verde Islands with this form. The type is in the Yale University collection.

CLAVELINA Savigny, 1816

As here employed, this genus is used in a comprehensive sense, including *Chondrostachys* MacDonald, 1858, *Podoclavella* Herdman, 1890, and *Rhodozona* Van Name, 1902, on the ground that the characters distinguishing these groups are unessential and purely superficial, depending mainly on the degree of separation of the zooids, which may each have a separate covering of test or may be more or less buried in a common mass of test, a character not even of specific value. Several other genera should probably also be included.

No reason is at present apparent to the writer why even the rank of a subgenus should be accorded to any of these groups. It would, however, certainly be premature to claim that a valid basis may not sometime be found for subdividing the genus *Clavelina*, taken in this comprehensive sense, into two or possibly more well-defined groups worthy of at least subgeneric rank. *Clavelina detorta* (Sluiter) from the Malay region, for instance, might be regarded as deserving of such separation on account of certain peculiarities in the form and structure of the zooids. But such subdivision of *Clavelina* should await more complete knowledge of the subject.

Since, as shown below, specimens undoubtedly belonging to *Clavelina* may have the zooids completely buried in a common mass of test and may have the stomach wall plicated, the distinction between *Clavelina* and the typical subgenus of *Polycitor* Renier, 1804, which is characterized by many rows of stigmata and a plicated stomach wall, apparently disappears, and *Clavelina* should perhaps be treated as a synonym of *Polycitor*. As no specimens of that subgenus have been available for study (the West Indian *Polycitors* are all of the subgenus

Eudistoma), this problem cannot be dealt with here, and the generic name *Clavelina* will be retained in the present article for the two following species.

***Clavelina oblonga* Herdman, 1880**

Figures 38, 39, and 53

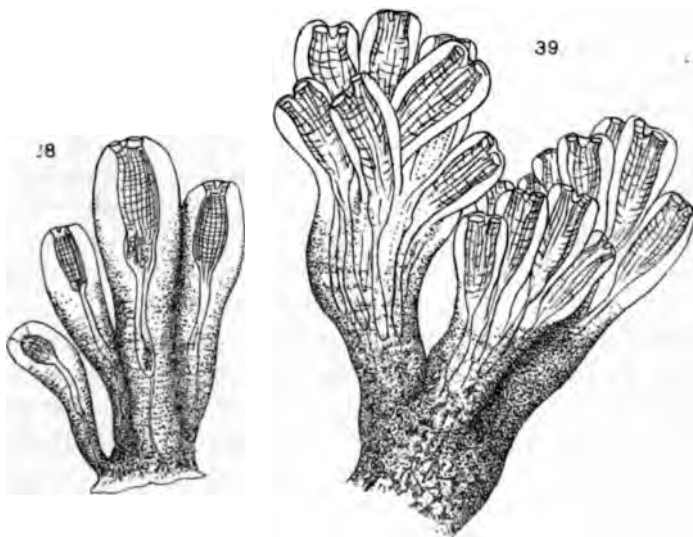
- 1880. *Clavelina oblonga* Herdman, Proc. Roy. Soc. Edinburgh, X, p. 724, figs. 93-95.
- 1882. *Clavelina oblonga* Herdman, 'Rept. Voy. Challenger, Zool.,' VI, p. 246, Pl. xxxv, figs. 6-10.
- 1890. *Stereoclavella oblonga* Herdman, Trans. Biol. Soc. Liverpool, V, p. 161.
- 1891. *Stereoclavella oblonga* Herdman, Journ. Linn. Soc. London, Zool., XXIII, p. 604.
- 1900. *Clavellina oblonga* + *Diazona picta* Verrill, Trans. Conn. Acad. Sci., X, pp. 588-591, Pl. lxx, fig. 8.
- 1902. *Clavelina oblonga* + *Rhodozonia picta* Van Name, Trans. Conn. Acad. Sci., XI, pp. 334, 335, Pl. xlvi, figs. 1, 3; Pl. xlvii, figs. 5, 7; Pl. lx, fig. 122; Pl. lxii, fig. 130a.
- 1907. *Rhodozonia picta* Seeliger, Bronn's 'Tier-reich,' III, suppl., p. 1208.
- ?1908. *Stereoclavella* species Hartmeyer, Year Book Carnegie Inst., Washington, No. 6, p. 111.
- 1909-1911. *Chondrostachys oblonga* + *C. picta* Hartmeyer, Bronn's 'Tier-reich,' III, suppl., pp. 1427, 1633.
- 1912. *Chondrostachys oblonga* + *C. picta* Hartmeyer, 'Deutsch. Tiefsee-Exp.,' XVI, p. 295.

The type of this species, collected by the Challenger Expedition and described and figured by Herdman (1882), consisted of a colony of about forty zooids or individuals, each with its separate covering of test, united only at the posterior end, where, according to Herdman's description, they "form a thick irregular stolon." In such colonies as the above the individuals are club-shaped, usually 20 to 30 mm. long (high) inclusive of the test; each is inclosed in a thick covering of test, which is wide and rounded at the summit or anterior end, where the two apertures are situated, and tapers into a narrow base by which it is attached to the other members of the colony through a basal mass of test containing branching vessels that may bear a few bulbs or enlargements.

Colonies of this type (Fig. 38) are frequent, but along with them are often found others in which the posterior half of each zooid (or a greater or less part of its length) is buried in the common basal mass of the colony; only their anterior parts have a separate and independent test covering; in immature or imperfectly developed colonies the entire length of the zooid may be thus buried, as it is in most compound ascidians, the colony consisting of one or more capitate lobes; in some

specimens this entirely buried condition persists even though the zooids have attained full size and fully adult condition.

The usual condition is, however, that of at least partial separation of the zooids; large colonies, which may include some hundreds of zooids and measure 160 mm. or more across, are made up of many lobes or groups of more or less intimately joined individuals. Fig. 39 shows a part of the colony comprising three such groups or lobes. *Diazona picta* Verrill, 1900, was based on a large colony of this character.



Figs. 38 and 39. *Clavelina oblonga* Herdman, 1880

Fig. 38. Small colony with separate zooids, $\times 1.8$. Fig. 39. Three lobes of a large colony with partially united zooids, $\times 1.8$. (In both figures the zooids are represented with the branchial sac expanded.)

The test is gelatinous, more or less perfectly transparent, sometimes entirely colorless, in other cases with a pinkish or violet tinge which may or may not be retained in preserved material. In some living specimens obtained at Bermuda, the zooids showed through the test as light yellowish, with the stomach and intestine deep yellowish brown. Some opaque white pigment was present about the apertures and elsewhere on the thorax. There was no pink or carmine color on any part of the specimens, but in some colonies, as in those described by Verrill as *Diazona picta*, there is a carmine ring about the oral aperture and often a stripe of the same color down the ventral side of the thorax of each zooid. A colony collected off Biscayne Bay, Florida, by Dr. Paul Bartsch, is

noted as "transparent with a delicate tinge of crimson." In alcoholic material the test generally loses some of its transparency; preserved specimens do not usually show conspicuous pigmentation, whatever may have been their condition during life, yet in one specimen the zooids exhibit a conspicuous ring of bright yellow pigment about the oral aperture. This, of course, may have been some other color when fresh.

Zooids (Fig. 53, p. 377) very variable in size in different colonies; in some their length is quite uniform, in others it is not at all constant. Large zooids, well expanded, may reach 25 mm. long. In the ordinary, contracted, preserved condition they do not usually exceed half or two-thirds this length. A vascular process from the posterior end of each zooid joins it to the branching stolons in the base of the colony. Thorax of zooid large, oval when contracted, more barrel-shaped in expansion; the orifices on very short tubes at the anterior end, the branchial orifice being the larger of the two. The abdomen or posterior part of the body is long and narrow. Sphincter muscles of apertures not very strong. Both apertures frequently have six distinct lobes; in other specimens the border may be merely sinuous or even perfectly plain.

Mantle musculature developed mainly on the thorax, where there are rather slender longitudinal muscle bands, rather widely spaced, and underlying them a somewhat larger number of narrower, less perfectly formed, transverse bands, so that an open network of square or oblong meshes is formed.

Tentacles not very numerous; in a large individual only about thirty were demonstrated. They represent three orders.

Dorsal tubercle of plain oval form, longitudinally elongate.

Dorsal languets triangular, broad at the base. They arise directly from the median dorsal vessel and are continuous with inwardly projecting membranes which extend along the transverse vessels of the sac.

Branchial sac with from about ten to twenty-two rows of small oval stigmata; there are often forty or more in a row on each side. Transverse vessels stout, each provided with a membrane along the side toward the interior of the sac as above noted.

Intestinal loop long and very narrow; rectum extending only a short distance into the thorax. Stomach elongate oval, largest at the pyloric end, generally smooth-walled, with a single internal longitudinal ridge or typhlosole; yet in some colonies its wall exhibits about a dozen longitudinal folds which are sometimes so distinct and regular as to leave no doubt that they are permanently present, not due to contraction.

Reproductive organs beside the posterior part of the intestinal loop. The ovary, situated near the posterior end of the stomach, is sac-like and is prolonged into a stout oviduct which accompanies the ascending branch of the intestine. The oviduct is crowded with small eggs in some specimens. Testes small and pear-shaped, very numerous, forming a dense cluster near and posterior to the ovary. The common sperm duct accompanies the oviduct and intestine. The peribranchial cavity often contains numerous, small, tailed larvæ.

This is a common and widely distributed species, ranging from Bermuda and South Carolina to Brazil, and occurring both along the shore near low-water mark and in deeper water (to 28 fathoms), though apparently more abundant in shallower situations (not over 6 or 8 fathoms). Its great variability in size, color, appearance, form of the colony, and the degree of separation of the zooids have led to much disagreement and confusion as to its proper generic and specific name. Some of the colonies of this species are, from their large size, delicate structure, transparency and bright coloration, among the most beautiful members of the varied marine fauna of the West Indian region. Colonies in which the zooids are completely buried in a common mass of test are not always easily distinguishable from small examples of the next-described species; yet, in spite of the occasional occurrence of such perplexing specimens, the two species appear to be distinct, and with living or fresh specimens the difficulty might largely disappear. This species is found growing attached to a great variety of objects, stones, shells, corals, etc.; some of the largest and handsomest colonies grow on gorgonians. One very small one appears from the form of its base to have grown on the back of a small crab.

The type of this species was obtained by the Challenger Expedition of Bermuda, where it is common, and has also been collected by Professor Verrill (1901) and by myself along the shore and in depths of a few feet.

Hartmeyer (1912a) reports it from the Brazilian coast, and from St. Thomas and other West Indian localities, and would identify it with Lesueur's (1823) *Ascidia claviformis* from St. Vincent, but Lesueur's description and figure would apply also to *Ecteinascidia turbinata* (see p. 375), so that it seems advisable to retain Herdman's name.

The National Museum collection contains examples from numerous localities. Most of the specimens were dredged off the west coast of Florida from the vicinity of Cedar Keys southward to off Key West, at various depths down to 28 fathoms; several were from southeastern Florida and one large colony from the Blackfish Banks off Charleston, South Carolina.

At Porto Rico it was dredged by the American Museum Expedition at several points off the southern coast in from 15 to 42 feet, but the colonies were of small size.

***Clavelina gigantea* (Sluiter), 1919**

Figure 40

1919. *Polycitor giganteus* Sluiter, Bijdr. Dierkunde, Feestnummer, p. 10, Pl. 1, figs. 18-20.

The National Museum collection contains a number of specimens that appear to belong to this species, recently described by Sluiter.

40



Fig. 40. *Clavelina gigantea* (Sluiter), 1919
Vertical section through colony, natural size.

The colony is large and massive, sometimes consisting of two or more lobes or heads connected at the base, but in other cases it is undivided. In form the heads may be irregularly spherical, though more often they are pear-shaped, cuneate or capitate; a more or less well-defined thick peduncle may be developed, or it may merely be attached by a narrowed base. The surface of the colony varies from smooth to quite deeply pitted with small depressions over the positions of the zooids; the latter condition is probably largely artificial, due to the greater shrinkage of the zooids than the solid test substance. The test is, in the alcoholic specimens, rather hard and tough and somewhat opaque, in contrast to the transparent gelatinous character seen in well-preserved specimens of *C. oblonga*. Its color in life is uncertain. Some of the colonies, though they have been kept in alcohol for many years, are chocolate-brown, due to brown pigment in the test cells; others show no pigment at all, the test and tissues being of the usual yellowish white color. Whether these were originally unpigmented or are merely faded is not certain, but no intermediate, slightly pigmented specimens are in the collection.

The zooids are scattered and placed perpendicularly to the surface without being arranged in groups or systems. They are of large size, so that their posterior ends extend down into the central or even into the basal parts of the colony. The test immediately inclosing the body of each zooid is tougher and harder, forming a sort of sheath.

The size of the colonies (some of which may be lobes or divisions of more extensive colonies that have become separated) is quite variable; the larger heads do not ordinarily exceed 50 or 60 mm. in total height, including the narrowed basal part of peduncle, and a diameter in the upper portion of 30 or 35 mm., but there are a few specimens in which these dimensions are considerably exceeded. The zooids, though very variable in size, average considerably larger than in the last species, attaining in some of the colonies a length of about 30 mm., even in the preserved and not fully extended condition. In structure they so closely correspond to those of *C. oblonga* that no separate description or figure is needed. The rows of stigmata are, however, more numerous, sometimes over 30 in large zooids, with 70 or more stigmata in a row on each side, and the testes may be also exceedingly numerous. As in *C. oblonga*, the branchial and atrial apertures may be distinctly six-lobed, and the stomach wall may exhibit about a dozen distinct longitudinal plications, but either or both of these characters may be only obscurely developed or absent. Vascular appendages extend down into the lower part of the colony from the posterior end of the zooids, but they are not usually very conspicuous. The tentacles are of three orders; the normal total number is probably thirty-two, but the smaller ones are usually wanting in some of the intervals.

Sluiter describes the dorsal tubercle as U-shaped and I have also found it presenting this appearance, but believe that when this is the case it is due to a notch or interruption in the border of the tubercle, and that the actual orifice has merely an elongate oval form as usual in the genus. However, in very old and large zooids, such as those in Sluiter's specimen, an actual U-form may perhaps be developed.

The specimens here referred to this species were all obtained in the Gulf of Mexico at stations off the west coast of Florida, from the vicinity of Cedar Keys to that of Key West, except one from off the southern coast of Yucatan. The depths, where given, range from 6 to 28 fathoms; the bottom was sandy in a majority of cases where it was recorded. It is apparently not a littoral form.

Sluiter (1919) described the species to which they are here referred from a single colony of somewhat cylindrical form, 12 cm. high and 8 cm. in diameter, of a brownish color on the surface, containing very large zooids (4.5 cm. long). The specimen was from the West Indies, exact locality not given.

None of the National Museum specimens equal Sluiter's example in the size of the zooids, but this character is very variable in this group. A

much more serious discrepancy is that Sluiter found minute papillæ along the inner side of the transverse vessels of the branchial sac, while the best preserved specimens in the National Museum series show that a continuous plain-edged membrane, not a series of papillæ, is present. This difference, reported by so experienced an observer as Professor Sluiter, would seem to prevent regarding the two forms as identical, were it not for the fact that in more or less poorly preserved and laterally contracted zooids the edge of the membrane becomes sinuous and often notched and broken so as to strongly suggest a series of papillæ. In fact, in the first specimen examined, which happened to be rather poorly preserved, the writer was deceived in the same way, and spent some time in looking (of course in vain) for the internal longitudinal vessels of which he thought these supposed papillæ might be the supports.

No other character separates this species generically from *Clavelina oblonga* (indeed small and poorly developed colonies of the present species are difficult to distinguish from that form); it is, therefore, placed in *Clavelina* in this paper, since that generic designation is retained for *oblonga*.

CYSTODYTES von Drasche, 1884

Distinguished from *Polycitor* chiefly by possessing disk-shaped calcareous spicules in the test.

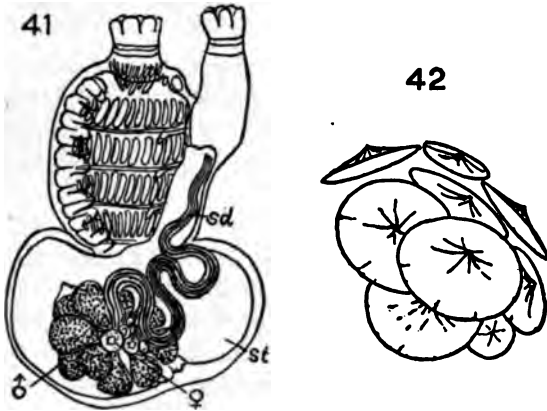
Cystodytes dellechiaiæ (Della Valle), 1877

Figures 41 and 42

- 1877. *Distoma dellechiaiæ* Della Valle, 'Contribuzioni alla storia naturale delle Ascidie composte del Golfo di Napoli,' p. 40 (*vide* Herdman).
- 1886. *Cystodytes draschii* Herdman, 'Rept. Voy. Challenger, Zool.,' XIV, p. 137, Pl. XIX, figs. 1-15.
- 1891. *Cystodytes draschii* Herdman, Journ. Linn. Soc. London, Zool., XXIII, p. 615.
- 1902. *Cystodytes draschii*+*C. violaceus* Van Name, Trans. Conn. Acad. Sci., XI, pp. 347, 348; Pl. XLVIII, figs. 12-14; Pl. XLIX, fig. 17; Pl. LVIII, figs. 99-101.
- 1907. *Cystodites draschei* Seeliger, Bronn's 'Tier-reich,' III, suppl., p. 1222.
- 1909. *Cystodites violaceus* Caullery, Bull. Sci. France et Belgique, XLII, p. 45.
- 1909-1911. *Cystodites draschei*+*C. violaceus* Hartmeyer, Bronn's 'Tier-reich,' III, suppl., pp. 1434, 1633, 1634.
- 1912. *Cystodites draschei*+*C. violaceus* Hartmeyer, 'Deutsch. Tiefsee-Exp.,' XVI, pp. 314, 373.
- 1915. *Cystodytes dellechiaiei*+*C. draschei* Michaelsen, 'Beitr. Meeresfauna Westafrikas,' I, p. 483.

The above references are those applying to this species as found in American waters. See below, p. 362.

Colony usually with a fairly even surface and with rounded edges, though in some places these may expand into a thin margin. Size of largest specimens 60 to 80 mm. across and about .5 mm. thick. Surface fairly smooth; color of colony varying from brown, blackish or purple (due to oval pigment cells in the test) to pale buff or almost white. Purple colonies turn brown in preservation. The pigment may or may not be abundant enough to conceal the white, calcareous capsules that close the posterior parts of each zooid, and into which they withdraw when they contract. They are built up of overlapping, thin, disk-like, slightly concave spicules (Fig. 42), .4 or sometimes .5 mm. or more across, though many of them are much smaller. Some of the spicules



Figs 41 and 42. *Cystodytes dellechiaiaze* (Della Valle), 1877

Fig. 41. Left side of zooid, $\times 32$. Fig. 42. Spicules, $\times 52$.

also be scattered in the basal parts of the colony, taking no part in forming any capsule. In many colonies, the capsules are poorly formed and the spicules are mostly very badly broken; sometimes the spicules are largely replaced by irregular granules of calcareous matter. The testis is largely composed of small, hollow bladder cells, as is the case in many other compound ascidians.

The zooids resemble those of the subgenus *Eudistoma* in most characters, but are proportionately shorter. The longitudinal muscles of the middle of the thorax form distinct bands, but the bands of each side of the body are gathered together into a single very broad, thick one on each side in the constricted middle part of the body. This serves to retract the anterior part of the body into the capsule formed by the spicules. In preserved specimens these strong bands generally violently

contract and distort the body, shortening it into some such form as shown in Fig. 41.

Apertures six-lobed, on well-developed tubes, the atrial tube much the longest.

Tentacles numerous, of three sizes; Herdman gives the number as about fifty. The smaller ones are inserted in a circle farther forward than the large ones.

Dorsal languets arising from the transverse vessels of the left side of the body.

Four rows of stigmata with at least a dozen in a row on each side. Intestinal loop short, stomach apparently round and smooth-walled; its wall is, however, thin and is usually thrown into folds in preserved specimens.

Reproductive organs beside the intestinal loop as in *Polycitor*, the common sperm duct accompanying the distal part of the intestine to near its end. Testes pear-shaped, ten or more in number in well-developed zooids. Ovary a group of eggs near the commencement of the common sperm duct.

In spite of considerable variations in color and in the size of the spicules and an unusually wide range in depth of habitat, the larger series of specimens now available leads me to doubt whether more than one species of this genus can be recognized in the West Indian region, and I follow Michaelsen (1915, p. 485) in identifying it with Della Valle's (1877) Mediterranean form, and in regarding several other Old World species, including *C. philippinensis* Herdman, 1886, from the Philippines (see Van Name, 1918) as synonyms or mere varieties of it. But with Michaelsen's course in separating Herdman's *C. draschii* as a distinct species merely for the reason that the bladder cells in the test of his type were not so closely crowded together as in some of the others, I must totally disagree. I cannot agree with Dr. Michaelsen's belief that two species can be separated on such a difference; it is, indeed, not even an individual character, as it no doubt varies in different stages of growth of the same colony. Herdman's *C. draschii* was obtained by the 'Challenger' at Barra Grande, Brazil, in 400 fathoms, a considerably greater depth than any of the other records, but it does not appear to differ from the rest in any important respect. At Bermuda this species is not uncommon on corals, gorgonians, etc., on the reefs, and I have collected it on stones along the shore. The National Museum contains specimens from shallow water off the west coast of Florida and from deeper situations, Station 7279, Steamer Fish Hawk (Gulf Stream off Key West, Florida, 98 fathoms,

sand) and Station 2333, Steamer Albatross (23° 10' 36" N., 82° 19' 12" W., 169 fathoms, fine white coral).

Holozoa Lesson, 1830

[= *Distaplia* Della Valle, 1881. Proposed *nomen conservandum*, *Distaplia*]

Branchial sac with four rows of stigmata, each row crossed at its middle by a slender transverse (dorsoventral) vessel. Development of the embryos (in the typical species, at least) takes place in a large pouch or external diverticulum of the peribranchial cavity into which the oviduct passes.

Holozoa bermudensis (Van Name), 1902

[*Distaplia bermudensis* under proposed system of *nomina conservanda*]

Figure 43

?1870. *Cellulophana collectrix* O. Schmidt, 'Grundz. Spongienf. Atlant. Geb.,' p. 25.

1902. *Distaplia bermudensis* Van Name, Trans. Conn. Acad. Sci., XI, p. 349, Pl. XLIX, figs. 15, 18, 19; Pl. LIX, figs. 108, 111; Pl. LXII, fig. 130b.

1909. *Distaplia bermudensis* Caullery, Bull. Sci. France et Belgique, XLII, p. 45.

1909-1911. *Holozoa bermudensis* Hartmeyer, Bronn's 'Tier-reich,' III, suppl., pp. 1437, 1633.

1911. *Holozoa bermudensis* Hartmeyer, 'Deutsch. Südpolar-Exp., Zool.,' XII, p. 486.

Form of colony very variable, sometimes capitate, consisting of one or more heads, usually somewhat flattened on top with rather abrupt sides tapering into a short peduncle; in other cases it forms a flat in-crusting sheet, commonly 4 or 5 mm. thick and often several centimeters across. The colony may, however, have any of an infinite variety of intermediate forms. The heads in the capitate colonies may reach a diameter of 20 mm. or more. They are rarely of very symmetrical form. Colors of the colonies as variable as their shape, often very brilliant during life, but usually fading to a green, blue-green, yellowish or olive tint in preserved material, though some alcoholic specimens are reddish or pink, or are mottled or marbled with areas of greenish or blue-green and red or pink. As a rule, the basal parts of the colony are pale, the upper portions darker, sometimes shading into blackish. The colors of living specimens are much more varied and beautiful, often chocolate-brown, shading into or marbled with olive, violet, purple, black, rose color, or even an intense orange-red; any one of these colors may predominate. White pigment is often present about the orifices. These colors are chiefly due to oval pigment cells in the test.

Test translucent or semitransparent; surface of the colony not shiny. Zooids arranged in systems, sometimes composed of but few zooids, in other cases extensive and complex. Vascular processes,

straight and unbranched, extending down from the posterior ends of the zooids, are often conspicuous in the basal parts of the colonies.

Expanded zooids may measure over 3 mm. long and 1.3 mm. across the thorax, even in preserved material, but are much subject to shrinkage owing to the delicacy of their tissues, which are often beautifully transparent. Mantle musculature slight, consisting chiefly of very delicate bands in the thorax, which run mostly in an oblique direction.

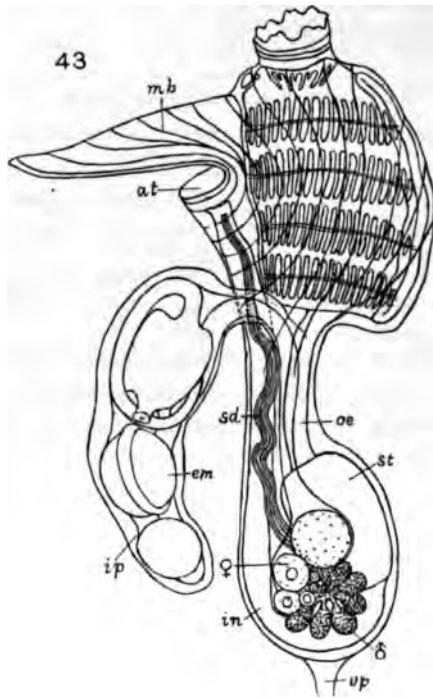


Fig. 43. *Holozea bermudensis* (Van Name), 1902

Right side of zooid with incubatory pouch containing three embryos or larvae, $\times 30$.

This is in strong contrast to the condition prevailing in the genus *Polycitor*, where there are very powerful longitudinal bands on the thorax. Even the sphincter of the branchial orifice is comparatively weak in the present genus. Margin of branchial orifice with irregular rounded teeth or crenations; when contracted often appearing plain. Atrial orifice large, smooth-margined, its anterior lip produced into a large languet.

Tentacles about sixteen, of two sizes placed alternately.

Dorsal languets long and narrow.

Branchial sac with four rows of long narrow stigmata. The delicate structure of the sac and its consequent liability to folding and distortion makes accurate counting of the stigmata difficult. An examination of some unusually favorable material indicates a somewhat smaller number of stigmata than given in my original description; there are probably fifteen or nineteen in a row on each side. Those of each row are crossed, without being interrupted, by a delicate intermediate transverse vessel.

Stomach elongate-oval, tapering toward the pyloric end. In all of any zooids from different colonies and localities, its walls were found to be smooth within and without, except for a minutely granular roughness, visible on considerable magnification, and for a single, internal, longitudinal ridge or typhlosole. Stomach and proximal part of intestine orange or yellow during life.

Zooids hermaphroditic; reproductive glands on the right side of the testinal loop. The small, oval testes (about ten to twelve in number) and the ovary lie close together. The thick-walled sperm duct accompanies the ascending branch of the intestine. The delicate, thin-walled duct does also for a distance, then enters the incubatory pouch. This structure is not present on all zooids, and in many colonies none will be found on any of them. Apparently it develops only when needed to receive the embryos. It is a large, elongate, curved, tapering evagination. The wall of the right posterior dorsal part of the peribranchial cavity is connected with the body of the zooid by a neck too narrow to allow the embryos to pass out again when they have attained their growth, and they escape by bursting the walls of the pouch and the surrounding testis. The embryos are arranged in the pouch in one row, the testis in the proximal part. Often pouches with their contents of developing young are found lying in the testis unattached to any zooid, having broken away, or the zooids originating them having died and been absorbed.

This species appears to be well differentiated from the well-known *H. vata* Sars of the northern seas of Europe and America (see Van Name, 1910), but its relationships to the Mediterranean species require further investigation. Perhaps it may be identical with *Cellulophana collectrix* (Schmidt, 1870, from Tortugas, Florida, described as a sponge. The specimens in the collections studied show its range to include Bermuda (the type locality), South Carolina, Florida (both coasts), Porto Rico,

and the former Danish West Indies. It is a shallow-water species which grows on stones, piles, corals, and a great variety of other objects, including other species of ascidians, but a specimen from off the northern part of the South Carolina coast was dredged in 15 fathoms and a poor and somewhat doubtful one in 27 fathoms off the west coast of Florida. These are the deepest records. It is one of the commonest shallow-water species at Bermuda and at St. Thomas, W. I. At Porto Rico it was found common along the shores of Guanica Harbor, and was also dredged off the mouth of that harbor in 5 fathoms and near the mouth of Guayanilla Harbor in 15 feet. One colony was also obtained in San Juan Harbor below San Antonio bridge.

***Holozoa bursata*, new species**

[*Distaplia bursata* under proposed system of *nomina conservanda*]

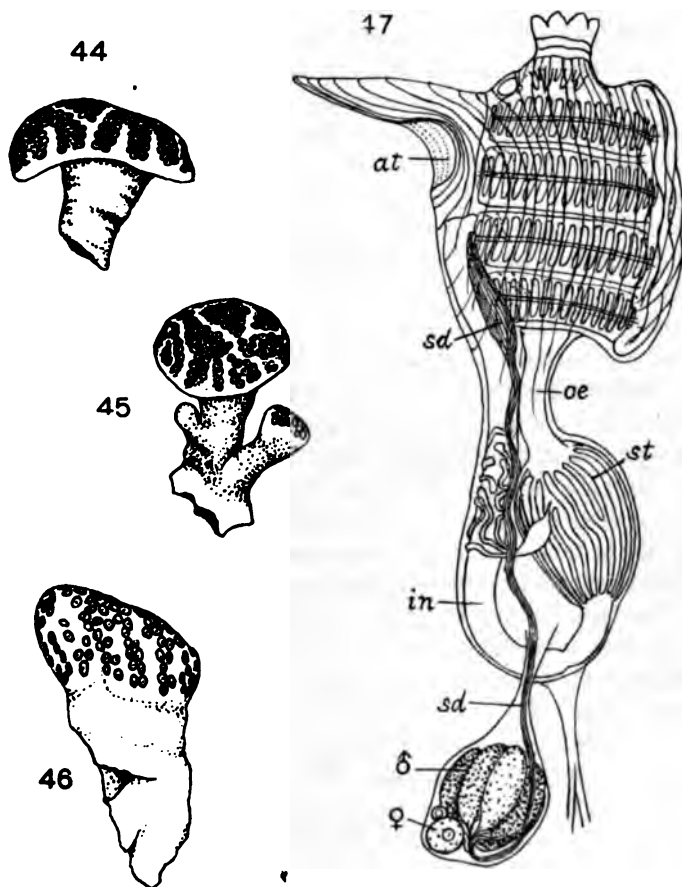
Figures 44-47

The best-developed colonies in the collection exactly resemble ordinary mushrooms in shape, consisting of a broad head, convex above and slightly concave below, mounted on a thick pedicel approximately equaling or exceeding the diameter of the head in height. Size of one of the largest heads 17 mm. in greatest diameter and 15 mm. in height, inclusive of the pedicel, which is not complete at the base; the pedicel enlarges toward the top and has an average diameter of 6 to 7 mm. Several of the colonies have one or two smaller heads arising from the lower part of the pedicel where it is more or less expanded into a base for attachment. Some of the heads exhibit the mushroom form only imperfectly, having nearly the capitate shape seen in many other compound ascidians (Fig. 46); sometimes this appears to be due to immaturity of the colony.

The zooids are arranged in the central part of the upper surface of the heads in several small, irregularly formed systems; branches from these systems extend radially toward the margin of the heads. In most of the specimens the test is of a light yellowish-brown color and rather opaque, the parts occupied by the zooids and common cloacal cavities and canals showing darker brown in conspicuous contrast to the other parts of the colony, but in one lot of specimens (from Station 2136) the test is a dark grayish brown and the systems are inconspicuous. In many places in the test (both of the heads and pedicels) are minute white grains which appear to be intracellular deposits. They dissolve in acids.

The zooids have a rather short but wide thorax, connected by a moderately long thick neck with the abdomen; arising from the latter is

a pear-shaped or oval sac-like post-abdomen, containing the reproductive organs and much resembling the post-abdomen of *Polyclinum*. Apparently, however, it does not contain the heart. It is connected with the abdomen by a very narrow and often considerably elongated neck, which



Figs. 44-47. *Holozoa bursata* new species

Figs. 44-46. Colonies, $\times 1.3$. (Fig. 44 is the type.) Fig. 47. Right side of zooid, $\times 55$.

arises from the right posterior part of the abdomen and extends either in nearly direct prolongation of the main axis of the body of the zooid, or makes more or less of an angle with it. The zooids average small in size; even including the above-described pouch the total length in the somewhat contracted preserved material often does not exceed 2 mm.

Branchial aperture on a short tube; provided with six well-developed simple lobes; atrial region of very delicate structure, the aperture with a very thin and easily torn margin, so that its natural form is very hard to determine and is probably in fact variable according to the relations of the zooid to the common cloacal cavity or canal. In some zooids it appears to be produced in a tubular form, in others only the anterior margin appears to be much extended, forming a broad thin languet. The mantle is very delicate and transparent; on the thorax on each side there are numerous (over 20) very slender but well-defined muscle bands, quite regularly spaced and mainly longitudinal in direction. There is no distinct sphincter about the atrial orifice.

The normal number of tentacles appears to be sixteen, larger and smaller alternating, but the small ones are often wanting in some of the intervals.

Three dorsal languets are present, arising slightly to the left of the median dorsal vessel.

The branchial sac has four rows of stigmata; there are, as is characteristic of this genus, additional slender vessels crossing all the stigmata of each row at their middle point. They lie on the internal aspect of the sac and are not always easy to demonstrate. Fifteen stigmata in the anterior rows and thirteen in the last rows were present on each side in one zooid in which an exact count could be made, some individuals apparently having a few more than this (at least eighteen in the anterior rows). The loop formed by the alimentary tract is not twisted. The stomach is of the ovoid shape usual in this genus and has about eighteen or twenty slightly irregular longitudinal plications which are distinct, though not very deep. A little way posterior to its anterior end the stomach is joined by the duct from the tubular gland that surrounds the ascending branch of the intestine. This duct may be expanded into a fusiform vesicle between the intestine and the stomach; the tubules of the gland itself are crooked with more or less enlarged tips. The intestine often exhibits a more or less distinct constriction a short distance beyond the stomach.

The post-abdomen described above is completely filled by the reproductive organs. There are about six large pyriform testes situated in a circular group filling the proximal three-fourths of the post-abdomen; their sperm ducts arise from their distal (posterior) ends and immediately join to form the common duct which, passing forward beside the testes and through the neck into the abdomen, crosses on the right of the posterior part of the intestinal loop and follows the ascending branch of the

latter, lying along its right ventral aspect. In some individuals the terminal part of the sperm duct (alongside the rectum) is much distended with spermatozoa. The ovary consists of a group of a few eggs in different stages in the extreme end of the post-abdomen. An oviduct accompanying the sperm duct was not satisfactorily demonstrated. The reason for this may, however, have been the poor development of the ovaries, which were small and in some individuals were not found at all. The male organs, on the other hand, were well developed and evidently functional. Neither was an incubatory pouch for the development of the embryos found in the specimens studied, but it may be developed at certain stages, as in other members of the genus.

The specimens, about ten in number, are from three localities, as follows: Marco, Florida, "on beach," collected by Henry Hemphill (includes type); Key West, Florida, Steamer Albatross, April 15-27, 1884; and from southeast of Jamaica (Station 2136, Steamer Albatross, 17° 43' 40" N., 75° 38' 25" W., 52 fathoms, coral and broken shells). The specimens labeled "on beach" were very likely washed up from deeper water. Type in U. S. National Museum.

It is evident from the above description that this species differs considerably from the typical members of the genus *Holozoa*, such as *H. bermudensis* just described, even though we must regard the post-abdomen of the present species merely as a diverticulum of the abdomen and not as homologous with the post-abdomen of the Synoicidæ, which contains, besides the reproductive organs, the heart, pericardium and epicardium. A very similar species is *H. mikropnoa* (Sluiter) of the Australian and Malayan region (see Hartmeyer, 1920, p. 130). That form has, however, among other differences, only nine or ten stigmata in a row on each side and appears to have the sexes separate, while many, if not all, individuals of the present species are hermaphroditic.

PHLEBOBRANCHIATA Lahille

[= Diktyobranchia Seeliger]

A rather well-defined, though heterogeneous, group of simple and compound ascidians having a system of internal longitudinal vessels (though in a few cases these are rudimentary or lost), but no large folds in the branchial sac. Tentacles always simple, gonads on one side only, in immediate vicinity of digestive tract.

Diazonidæ Garstang, 1891

A small family, having the body divided, as usual in compound forms, into thorax and abdomen and the dorsal lamina replaced by a row of languets, but distinguished by possessing internal longitudinal vessels (usually well developed) and many rows of stigmata in the branchial sac.

RHOPALÆA Philippi, 1893[= *Rhopalæa* + *Rhopalopsis* Herdman, 1890]

The two genera are united on the ground that they differ in no essential character, except that *Rhopalæa* is said not to reproduce by budding. *Rhopalopsis* is, however, apparently more often found solitary than compound and never forms colonies of more than a few slightly connected individuals, while evidence that *Rhopalæa* never buds is very insufficient. The genus is distinguished by the large, completely or nearly completely separated zooids and the thick, hard test.

Rhopalæa abdominalis (Sluiter), 1898

Figures 48-51

1898. *Ciona abdominalis* Sluiter, Mém. Soc. Zool. France, XI, p. 8, Pl. I, figs. 3-8.
 1909-1911. *Ciona abdominalis* Hartmeyer, Bronn's 'Tier-reich,' III, suppl., pp. 1414, 1630.

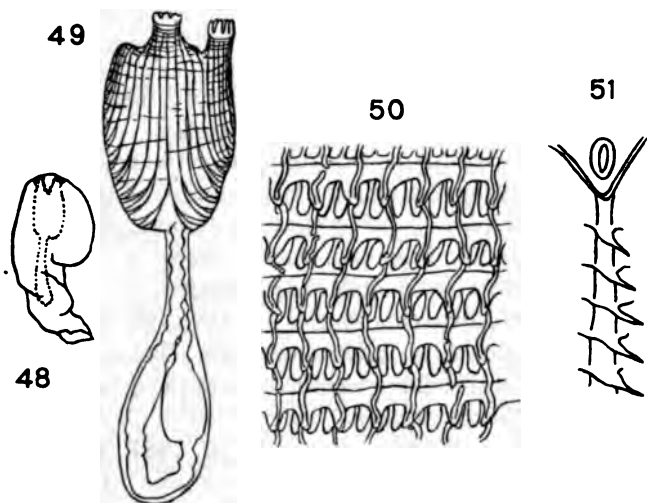
Of the few specimens of this species that were collected, only one shows any evidence of budding, consisting of several small individuals united by their basal portions into an irregular group; the other specimens each consist of a single individual only.

Though the body of the animal when removed from the test has the form usual in compound ascidians, consisting of a thoracic and an abdominal part united by a constricted neck, the external form is exceedingly variable and usually quite irregular, owing to the great and uneven thickness of the test. The normal form is evidently club-shaped, with the anterior end large and rounded; the posterior part of the body is usually narrower, though irregularities in the thickness and outline of the test may alter these relations. The attachment is in most cases by the greater part of one side, leaving, however, the anterior part of the body more or less free. External length of largest individual 24 mm., greatest width about 10.5 mm.; when removed from the test, the body in its somewhat contracted state may be only from one-half to two-thirds of the external length.

Test free from incrusting foreign matter and smooth externally except for a few slight wrinkles, which are probably due to shrinkage in preservation. It is semitransparent, slightly cartilaginous in character and not very tough, though a thin inner layer of a much tougher consistency immediately incloses the abdominal part of the body of the animal. The color of the alcoholic specimens is carmine pink or somewhat violet-pink, shading toward a deep carmine on the anterior part of the body, especially about the apertures; the color is in part diffuse

e test, but also largely due to pigment cells and corpuscles of a deep
 rmine color in the mantle, in the vessels of the branchial sac, and else-
 here in the tissues of the zooids, especially on the anterior part of the
 ydy.

The apertures are on short, stout, anteriorly directed tubes, the
 anchial is rather irregularly lobed, the atrial has six deep rounded lobes.



Figs. 48-51. *Rhopalæa abdominalis* (Sluiter), 1898

Fig. 48. Outline of individual including test, slightly enlarged. Fig. 49. Individual removed
 from test, showing muscle bands on mantle, $\times 5.6$. Fig. 50. Piece of the branchial sac, $\times 56$. Fig.
 51. Dorsal tubercle and anterior part of median dorsal vessel with five of the dorsal languets, $\times 56$.

Mantle thin, with little musculature except the sphincters of the
 sices and about twenty distinct and strong longitudinal bands on each
 e of the thorax; toward their posterior ends these bands curve toward
 e median dorsal or ventral line (according to whether they are nearer
 e dorsal or ventral aspect), so that they become nearly transverse,
 d at the same time they divide into several narrower, somewhat diverg-
 g bands. The abdominal walls are thin and without conspicuous
 muscle bands.

Tentacles rather few in number, though several different sizes or
 orders are represented.

Orifice of dorsal tubercle oval, longitudinally elongate.

Dorsal lamina represented by narrow, triangular, transversely ex-
 tended languets arising directly from the median dorsal vessel.

Branchial sac with about forty rows of very small and numerous stigmata; the rows are separated by transverse vessels bearing small triangular papillæ which support a well-developed system of internal longitudinal vessels. These vessels connect with the supporting papillæ a little below the tips of the papillæ, so that the tips project into the branchial cavity a very little beyond the level of the internal longitudinal vessels. There are over forty of these vessels on each side. With the transverse vessels they form meshes which appear to usually contain only two stigmata.

The intestinal loop is rather long and narrow; the stomach is oval; definite plications in its wall were not demonstrated.

The reproductive organs are situated beside the intestinal loop and consist of a saccular ovary containing a large number of small eggs and of very numerous, small, pear-shaped testes, the common duct from which accompanies the ascending branch of the intestine.

The specimens are from the following localities:

Station 2413, Steamer Albatross, March 19, 1885, 26° N., 82° 57' 30" W., 24 fathoms, fine sand and broken shells. Three specimens (one consisting of several zooids; whether or not the others were part of the same colony is uncertain).

Station 2138, Steamer Albatross, February 29, 1884, 17° 44' 05" N., 75° 39' W., 23 fathoms, coral and broken shells. One individual.

Station 7511. Steamer Fish Hawk, off Cape Florida, in Gulf Stream, 2½ miles SSE. of Fowey Rocks Light. Rocky, 45 fathoms. One individual.

All the above in the National Museum collection.

There does not seem to be much question that these specimens are of Sluiter's species which clearly belongs to this group of ascidians and not to *Ciona*. His type was larger than any of them, being 35 mm. long, and it lacked the pink or carmine coloration of the present specimens, but it may have become faded. It was obtained at Tortugas Island in 45 meters. Whether it is a valid species or identical with some Old World form seems open to question.

Phallusiidæ (proposed *nomen conservandum* Ascidiidæ)

[= Ascidiidæ, s. Phallusiidæ *auct. omn.* + Perophoridæ Giard, 1872]

Body not divided into thorax and abdomen. The digestive and reproductive organs lie beside the branchial sac on the left side of the body.

Branchial aperture most frequently with eight or seven lobes, the atrial aperture with six.

Tentacles simple and filiform.

Dorsal lamina a continuous (often toothed) membrane, or replaced by a series of languets.

Branchial sac with internal longitudinal vessels (which often bear papillæ), but no large folds.

Reproductive organs in, or spreading over the surface of, the intestinal loop.

For reasons for uniting the Phallusiidæ and Perophoridæ, see p. 292. The question of whether the family Cionidæ Lahille, 1887, should not also be included need not be considered here, as it has not yet been proved to inhabit this region. Its typical genus *Ciona* approaches the Diazonidæ in some characters, rather than the Phallusiidæ.

PEROPHORA Wiegmann, 1835

Compound ascidians with small zooids having only four rows of stigmata. In our species the zooids are entirely separate, connected only by a branching stolon. Dorsal lamina represented by languets.

***Perophora viridis* Verrill, 1871**

Figure 52

- 1871. *Perophora viridis* Verrill, Amer. Journ. Sci., (3) II, p. 359.
- 1872. *Perophora viridis* Verrill, Amer. Journ. Sci., (3) III, p. 212.
- 1873. *Perophora viridis* Verrill and Smith, 'Rept. on Invert. Animals of Vineyard Sound,' pp. 702, 388, 401.
- 1879. *Perophora viridis* Verrill, 'Preliminary Check-list of Marine Invertebrata,' p. 27.
- 1889. *Perophora viridis* MacDonald, Rep. U. S. Comm. Fish and Fisheries for 1886, p. 858.
- 1891. *Perophora viridis* Herdman, Journ. Linn. Soc. London, Zool., XXIII, p. 602.
- 1897. *Perophora viridis* Lefevre, Anat. Anzeiger, XIII, p. 474.
- 1898. *Perophora viridis* Lefevre, Journ. Morphology, XIV, p. 369.
- 1898. *Perophora* species, Davenport, Science, new series, VIII, p. 687.
- 1898. *Perophora viridis* Bumpus, Science, new series, VIII, p. 853.
- 1900. *Perophora viridis* Wilson, Amer. Naturalist, XXXIV, p. 354.
- 1900. *Perophora viridis* Metcalf, Zool. Jahrbücher, Anat., XIII, p. 508, Pl. xxxiv, fig. 14 (ganglion, neural gland, etc.).
- 1900. *Perophora viridis* Herdman, Trans. Biol. Soc. Liverpool, V., pp. 158, 159.
- 1902. *Perophora viridis* Van Name, Trans. Conn. Acad. Sci., XI, p. 337, Pl. XLVII, fig. 8.
- 1905. *Perophora viridis* Seeliger, Bronn's 'Tier-reich,' III, suppl., p. 981 (budding).
- 1909-1911. *Perophora viridis* Hartmeyer, Bronn's 'Tier-reich,' III, suppl., pp. 1410, 1633.
- 1910. *Perophora viridis* Van Name, Proc. Boston Soc. Nat. Hist., XXXIV, p. 357, text fig. 3.
- 1913. *Perophora viridis* Miner, Amer. Museum Journ., XIII, p. 91.
- 1913. *Perophora viridis* Sumner, Osburn and Cole, Bull. U. S. Bureau of Fisheries, XXXI, pp. 155, 158-160, 730, 731; chart 193.
- 1916. *Perophora viridis* Pratt, 'Manual Common Invert. Animals,' p. 668.

The small ovoid bodies of the zooids of this species, which measure from 2.5 to 3.5 mm. in greatest diameter (length), are borne on the tips of the branches of a slender stolon which grows like a vine over shells, algæ, other ascidians, or other submerged objects in shallow water. The zooids have a thin, transparent covering of test; their tissues are usually transparent and colorless, except for some yellowish or greenish pigment

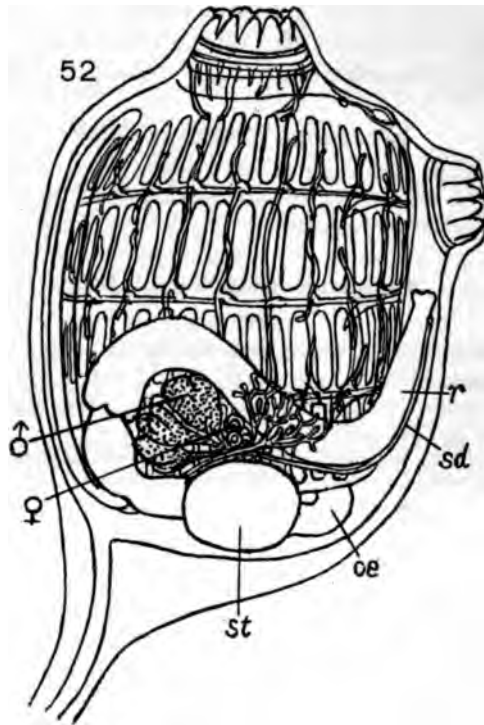


Fig. 52. *Perophora viridis* Verrill, 1871

Left side of zooid, $\times 27$.

contained in branching vessels in the mantle, which, aside from the sphincters of the apertures, has only a few slender longitudinal and oblique muscle bands. Apertures with a variable number of lobes.

Tentacles about twenty-four, of three sizes or orders.

Three languets represent the dorsal lamina.

Branchial sac with four rows of long stigmata; over twenty in a row on each side. Transverse vessels provided with inwardly projecting papillæ which support an incompletely developed system of internal

longitudinal vessels. These are separated by the width of about two stigmata.

Digestive tract forming a fairly large loop lying beside the branchial sac on the posterior part of the left side of the body, as in most simple ascidians. Stomach small, ellipsoidal.

Reproductive glands lying in the intestinal loop. Male glands pear-shaped or cuneate; arranged in a fan-like manner about the origin of the common sperm duct with which they communicate by small individual ducts. Their number varies in different individuals; in some zooids some or most of the individual glands are fused together into a large mass, though this may be incompletely divided by clefts into lobes representing the individual glands. The common sperm duct accompanies the rectum. Ovary situated beside the origin of the common sperm duct.

This animal is common on the southern New England coast, at Beaufort, North Carolina, and also at Bermuda. Hartmeyer (1908) reports a member of this genus (presumably this species) at Tortugas, Florida. At Porto Rico it was collected at Ponce along the shore and off Point Brea in $9\frac{1}{2}$ fathoms.

P. banyulensis Lahille, 1887, is a closely allied, if really distinct, Mediterranean form.

Ecteinascidia Herdman, 1880

Differs from *Perophora* chiefly in the elongated branchial sac with many rows of stigmata.

Ecteinascidia turbinata Herdman, 1880

Figure 54

- ?1823. *Ascidia claviformis* Lesueur, Journ. Acad. Nat. Sci. Philadelphia, III, p. 5, Pl. 1, fig. 3.
- 1880. *Ecteinascidia turbinata* Herdman, Proc. Royal Soc. Edinburgh, X, p. 724.
- 1882. *Ecteinascidia turbinata* (? part) Herdman, 'Rept. Voy. Challenger, Zool.,' VI, p. 243, Pl. xxxvi, figs. 1-6.
- 1886. *Ecteinascidia turbinata* Sluiter, Natuurk. Tijdschr. Nederl. Ind., XLV, pp. 169, 171.
- 1887. *Ecteinascidia turbinata* van Beneden, Bull. Acad. Roy. Soc., Belgique, (3) XIV, p. 28.
- 1890. *Ecteinascidia turbinata* Herdman, Trans. Biol. Soc. Liverpool, V, pp. 148, 160.
- 1891. *Ecteinascidia turbinata* Herdman, Journ. Linn. Soc. London, Zool., XXIII, p. 602.
- 1897. *Ecteinascidia turbinata* Lefevre, Anat. Anzeiger, XIII, p. 474, figs. 1-6 (budding).
- 1897. *Ecteinascidia turbinata* Lefevre, Science, new series, V, p. 433.

1900. *Ecteinascidia turbinata* Verrill, Trans. Conn. Acad. Sci., X, p. 588.
 1900. *Ecteinascidia turbinata* Metcalf, Zool. Jahrbücher, Anat., XIII, pp. 507—588, Pl. xxxiv, fig. 12; Pl. xxxviii, fig. 65.
 1902. *Ecteinascidia turbinata* Van Name, Trans. Conn. Acad. Sci., XI, p. 338—Pl. XLVII, figs. 4, 6; Pl. LIX, fig. 116. (Young individuals.)
 1906. *Ecteinascidia turbinata* Rennie and Wiseman, Proc. Zool. Soc. London, p. 905, Pl. LXV, fig. 12.
 1909–1911. *Ecteinascidia turbinata* Hartmeyer, Bronn's 'Tier-reich,' III, suppl. pp. 1412, 1614, 1633.
 1918. *Ecteinascidia turbinata* Michaelsen, Jahrb. Wiss. Anst., Hamburg, XXXV, suppl. 2, pp. 65, 67, 68.

The colony in this species consists of a dense group or cluster of elongate, somewhat club-shaped zooids, each with its own separate covering of test, which are connected by their tapering bases with a network of stolons that adheres to the surface of the object on which the colony grows. Mangrove roots and turtle grass are among the most frequent bearers of such colonies; in such cases the colony generally entirely surrounds the root or the grass, not infrequently for a length of 12 or 15 cm.

Zooids ordinarily about 20 mm. long or less, but occasionally larger. They are of oblong form, truncate at the anterior end where the two apertures are situated, and rather abruptly tapered at the other end to a narrow pedicel containing the vessel that connects the individual with the rest of the colony.

Test transparent and colorless, thicker on the ends of the body. Mantle and internal organs also very transparent, but in the living zooids and in specimens not too long preserved, this shades into yellow, orange, or pinkish orange on the anterior part of the body, the color being largely due to pigment in cells in branching vessels in the mantle. The intestinal loop is colored yellow or orange. A large colony of this species that the writer collected on mangrove roots at Plantation Key, Florida, had the zooids almost entirely bright orange during life, but most of this color quickly faded out on preservation, remaining only on the anterior part of the body.

Apertures on short tubes or slight elevations which often do not project beyond the surface of the thick layer of test covering this end of the body. Margin of apertures thin; when expanded it varies from practically plain to quite deeply and irregularly sinuate. In contraction it is always more or less sinuate. The branchial aperture is larger and a little farther forward than the atrial, though both are usually directed straight forward.

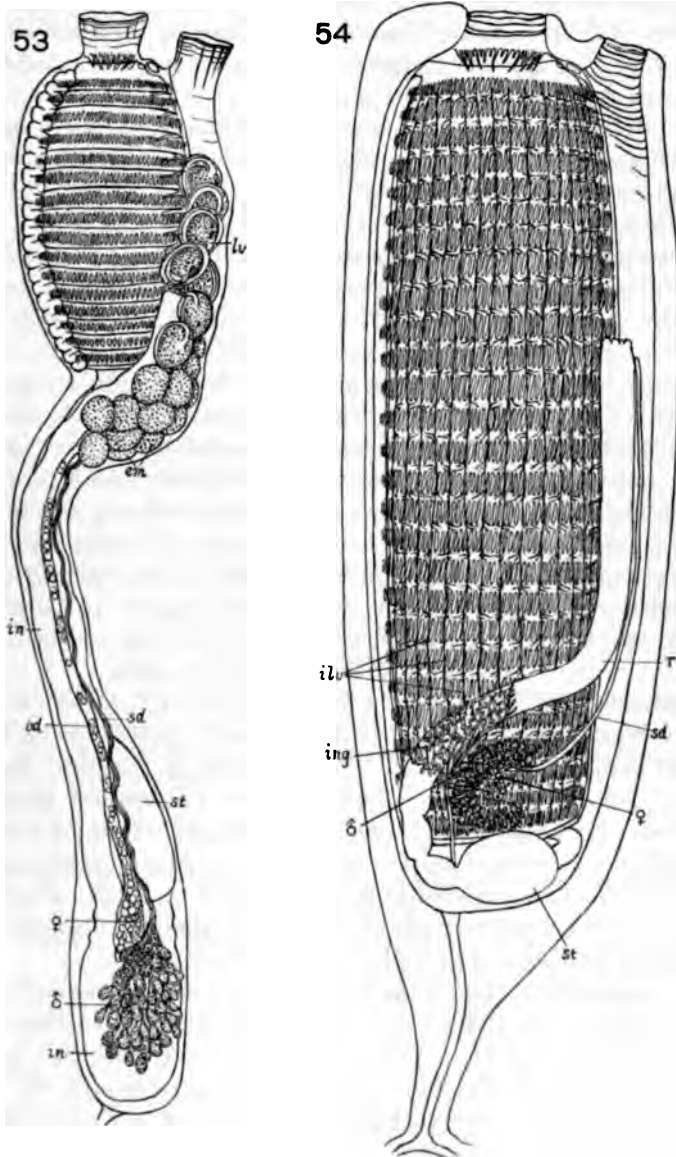


Fig. 53 *Clavelina oblonga* Herdman, 1880

; side of sooid (branchial sac contracted; embryos and larvæ in peribranchial cavity). $\times 10.5$

Fig. 54. *Ecteinascidia turbinata* Herdman, 1800

Left side of sooid, $\times 7.2$.

Mantle musculature slight. The sphincters of the apertures consist of slender slightly separated bands, and numerous very narrow transverse bands cross the dorsal region and extend down the sides, but are wanting on the ventral regions.

Tentacles filiform, quite numerous and of three sizes in large individuals, and arranged with considerable regularity. A specimen 20 mm. long had between thirty and forty tentacles.

Dorsal tubercle elongate oval.

Dorsal lamina a continuous membrane which is extended into a well-developed languet at each transverse vessel. Or it may be described as a series of languets connected by a basal membrane. It lies turned over toward the right side of the body.

Branchial sac long, barrel-shaped, with about twenty-seven rows of small oval or elongate stigmata. They are rather irregular in width and to some extent also in length. There are about sixty in a row. At intervals of about three or four stigmata the transverse vessels bear small papillæ which support on their tip a system of exceedingly slender yet in most parts of the sac completely developed internal longitudinal vessels. The supporting papillæ have their bases broad in a direction parallel to the transverse vessels. Along the sides of the endostyle and the median dorsal vessel, the first internal longitudinal vessel may be incompletely developed, or represented only by its supporting papillæ.

Stomach elliptical, intestinal loop open dorsally, rectum long and straight, lying along the dorsal border of the branchial sac on the left side and ending about opposite the tenth row of stigmata from the anterior end in a slightly lobed aperture. Intestinal gland well developed. It encloses the ascending part of the intestinal loop for a considerable distance and consists of crooked branching tubules ending in minute bulbs. These tubules unite to a number of slender ducts which leave the intestine and converge to form a stout common duct that enters the intestine just beyond the pylorus, as in *Perophora*.

Reproductive organs in the bend of the intestinal loop. The male portion consists of a C-shaped or horseshoe-shaped group of small oval or lobed glands which lie more or less concentrically with the curvature of the intestine. The common sperm duct accompanies the rectum almost to the anus. The ovary consists of a cluster of eggs in the bend of the C-shaped group of testes. No oviduct was demonstrated.

Young zooids have the body shorter and more oval, the apertures more prominent and relatively farther apart, and the rows of stigmata less numerous than in the adult. They much resemble individuals of the genus *Perophora* in their appearance.

This animal is common and widely distributed, and is one of the most conspicuous ascidians of the West Indian region, on account of the large size and bright color of the colonies. It occurs in the shallowest situations; its habit of growing on mangrove roots and turtle grass has already been mentioned.

It is common at Bermuda (the type locality); southern Florida, (Plantation Key, Grassy Key, very abundant also on flats near Rabbit Key, Bay of Florida); and in the Bahamas (Andros Island). Lefevre (1897) collected it at Jamaica, the Steamer Albatross at St. Thomas (shore), Rennie and Wiseman (1906) report specimens from the Cape Verde Islands, and examples from Alexandria, Egypt, are mentioned by Herdman, 1882, though the last may belong to another species (see Michaelsen, 1918, p. 67). This animal may be identical with *Ascidia claviformis* Lesueur, 1823, from St. Vincent, but Hartmeyer, 1912a, has expressed a different opinion, identifying (doubtfully) *Clavelina oblonga* with Lesueur's species. Herdman (1906, p. 299) gives the present writer as authority for the statement that *Ecteinascidia thurstoni*, an Indian Ocean species, occurs at Bermuda. Professor Herdman must have had the present species (*E. turbinata*) in mind, as no other is known from Bermuda.

PHALLUSIA Savigny, 1816

[= *Ascidia auct. plur.* Proposed *nomen conservandum*, *Ascidia*]

Simple ascidians, often of large size, with characters as given above for the family. Papillæ present on internal longitudinal vessels. Dorsal lamina a continuous (often more or less toothed) membrane.

Phallusia nigra Savigny, 1816

[*Ascidia nigra* under proposed system of *nomina conservanda*]

Figures 55-58

- 1816. *Phallusia nigra* Savigny, 'Mém. s. l. animaux sans vertèbres,' II, part 1, p. 163, Pl. II, fig. 2; Pl. IX, fig. 1.
- 1820. *Phallusia nigra* Savigny-Oken, Isis, p. 803, figs. on Pls. IX and XI.
- 1823. *Ascidia atra* Lesueur, Journ. Acad. Nat. Sci. Philadelphia, III, part. 1, p. 2, Pl. I; fig. 2.
- 1852-1856. *Phallusia violacea* Gould, 'U. S. Exploring Exp.,' XII, p. 495, Atlas, p. 16, Pl. LII, fig. 610.
- 1878. *Ascidia nigra* Heller, Sitzungsber. Akad. Wiss. Wien, math.-nat. Kl., LXXVII, p. 92.
- 1880. *Ascidia nigra* Herdman, Proc. Roy. Soc. Edinburgh, X, p. 466.
- 1882. *Phallusia atra* Traustedt, Vidensk. Meddel. natur. For. Kjöbenhavn, ann. 1881, pp. 278, 286, Pl. IV, fig. 6; Pl. V, fig. 17.
- 1882. *Ascidia nigra* Herdman, 'Rept. Voy. Challenger, Zool.,' VI, p. 210.

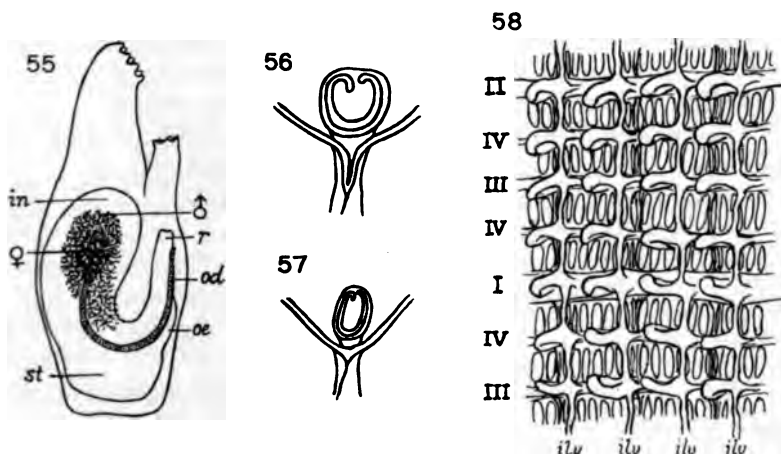
1884. *Ascidia nigra* von Drasche, Denk. Akad. Wiss. Wien, XLVIII, p. 383, Pl. VIII; figs. 5-7.
1891. *Ascidia atra* Herdman, Journ. Linn. Soc. Zool., XXIII, p. 592.
1897. *Ascidia atra* Metcalf, Zool. Bulletin, I, p. 143, figs. 1-4.
1898. *Ascidia atra* Sluiter, Mém. Soc. Zool. France, XI, p. 7.
1900. *Ascidia nigra* Verrill, Trans. Conn. Acad. Sci., X, p. 588.
1900. *Ascidia atra* Metcalf, Zool. Jahrbücher, Anat., XIII, pp. 500, 502, text figs. A-D.
1902. *Ascidia atra* Van Name, Trans. Conn. Acad. Sci., XI, p. 398, Pl. LXIII, figs. 138, 139.
1905. *Ascidia nigra* + *A. obocki* + *A. somaliensis* Sluiter, Bull. Mus. Hist. Nat. Paris, XI, pp. 100, 101; 1905a, Mém. Soc. Zool. France, XVIII, pp. 6-8, Pl. I, figs. 1-1c, 2-2b.
1908. *Thallusia nigra* Hartmeyer, Year Book of Carnegie Inst., Washington, No. 6, ann. 1907, p. 111.
- 1909-1911. *Phallusiopsis nigra* Hartmeyer, Bronn's 'Tier-reich,' III, suppl., pp. 1408, 1630, 1632-1634.
1912. *Phallusiopsis nigra* Hartmeyer, 'Deutsch. Tiefsee-Exp.,' XVI, pp. 361, 363.
1913. *Tunica nigra* Hilton, Zool. Jahrbücher, Anat., XXXVII, p. 113.
1916. *Phallusia nigra* Hartmeyer, Sitzungsber. Gesell. naturf. Freunde, Berlin, ann. 1915, p. 408, figs. 5-9.
1916. *Ascidia atra* Hecht, Journ. Exper. Zool., XX, p. 429.
1916. *Ascidia atra* Pratt, 'Manual Common Invert. Animals,' p. 667.
1918. *Ascidia atra* Hecht, Journ. Exper. Zool., XXV, pp. 229-299, figs. 1-6, 9, 10, 12; Amer. Journ. Physiol., XLV, pp. 157-187.
1918. *Phallusia nigra* Michaelsen, Jahrb. Hamburg. Wiss. Anst., XXXV, suppl. 2, p. 60.
1919. *Phallusia nigra* Michaelsen, Denk. Akad. Wiss. Wien, XCV, pt. 10, p. 113.

Body oval or somewhat elongate, usually more or less curved or distorted, broad and often inflated at the posterior end, but tapering toward the anterior end where the branchial aperture is situated, and more or less compressed laterally, especially in the anterior part, or sometimes throughout its whole extent. Atrial aperture usually on a short anteriorly directed tube or prominence, a little way back from the anterior end. The whole anterior part of the body is very commonly curved dorsally so as to bring the two apertures quite near together. This seems to be more or less characteristic of this species. Attachment by an area on the posterior or left posterior part of the body, sometimes by much of the left side.

Test thick and firm but not very tough. Color blue-black; surface smooth and shiny, with the exception of a few shallow furrows. The color, which pervades many of the internal structures as well as the test, is retained in preserved specimens. Very young specimens are colorless, but the dark pigment usually begins to appear when they are still very small.

The largest specimen in the Porto Rico collection measures even in a strongly curved condition 95 mm., and 45 mm. in transverse (dorso-ventral) diameter. A specimen from Bermuda 92 mm. by 47 mm. is in the American Museum, and Sluiter (1898) records one 110 mm. long.

Mantle dark colored, provided with many narrow longitudinal muscle bands crossed by slender and more closely placed transverse and oblique bands forming a fine network. On the right side the musculature extends the whole length of the body; on the left side the muscles disappear on the region covering the stomach and intestine.



Figs. 55-58. *Phallusia nigra* Savigny, 1816

Fig. 55. Left side of body slightly reduced. Figs. 56 and 57. Dorsal tubercles of two individuals.
 c 12. Fig. 58. Part of branchial sac, $\times 32$.

Tentacles of three or four sizes or orders, often arranged with some degree of regularity. The number is very variable (reaching 50 to 90 in fairly large specimens) and depends largely on the extent to which the small tentacles are developed, these being often almost or entirely wanting in some parts of the circle.

The dorsal tubercle was small and simple, usually with a U-shaped or horseshoe-shaped orifice, having the open interval directed forward with the horns more or less incurved, in the Bermuda and West Indian specimens in which this character was studied by the writer. Metcalf (1907) found numerous minute accessory openings leading from, and situated along, the neural duct in two large specimens from Jamaica; the orifice of the dorsal tubercle itself was of the normal form in these specimens. The ganglion and neural glands are very far back from the

dorsal tubercle in this species, and the neural duct is, in consequence, very long.

Dorsal lamina with transverse ribs along its left side and with small sharp serrations on its free margin. These are best developed on the posterior part.

Branchial sac with the minute undulations or plications characteristic of this genus well developed. Rather long, curved papillæ are borne on the internal longitudinal vessels at their intersections with the transverse vessels; intermediate papillæ are not present. Transverse vessels near together, of several sizes or orders, arranged with a variable degree of regularity in a different individuals. Stigmata in each mesh usually 5 to 10, depending on the amount of plication which is present. The branchial sac extends a little way posterior to the stomach.

Digestive tract rather large and strongly curved; stomach large. The whole tract covers more than half the area of the left side.

Reproductive organs only indistinctly visible through the mantle on account of the dark color of the latter. Some of the convoluted branches of the ovary are visible in the anteriorly extending loop of the intestine; the branching tubules of the male gland ramify over the visible parts of the ovary and the portions of the intestines adjacent to the ovary and proximal part of the oviduct.

This is one of the largest and certainly the most conspicuous of the simple ascidians found in West Indian waters, and is easily recognizable by its blue-black color and smooth surface, which appears to afford no secure basis of attachment for other organisms. It is widely distributed and common in shallow water, and has been reported from Bermuda, Tortugas, Florida, Jamaica, St. Croix, St. Thomas, St. Vincent, Guadeloupe, and the east coast of South America at the mouth of the Amazon, and Rio Janeiro. At Porto Rico it was found very common in Guanica Harbor on piles and mangrove roots. Several specimens were collected by Mr. Barnum Brown at Paradones, near Cienfuegos, Cuba, some of them growing in a cluster with *Pyura mcmus* form *pallida*. The National Museum collection contains specimens from other Cuban localities, from Curaçao and from off the west coast of Florida (21 fathoms).

The identity of the West Indian form with Savigny's *Phallusia nigra* from the Red Sea and Gulf of Oman (probably incorrectly reported also from the Cape of Good Hope by Herdman, 1882), which was for a long time in doubt, has been established by Hartmeyer (1909-1911, p. 1632: 1916, p. 413) by a direct comparison of specimens. Specimens recently received by the American Museum from the Bay of Djibouti appear to fully confirm this conclusion.

The physiology of this species is the subject of recent important papers by Hecht (1916, 1918) based on the study of specimens at Bermuda.

***Phallusia hygomiana* Traustedt, 1882**

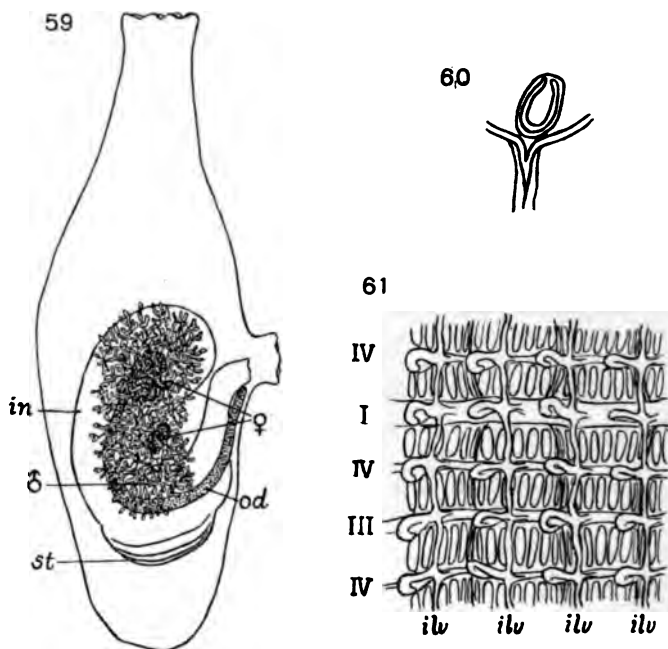
[*Ascidia hygomiana* under proposed system of *nomina conservanda*]

Figures 59-61

- ?1878. *Ascidia interrupta* Heller, Sitzungsber. Akad. Wiss. Wien, math.-nat. Kl., LXXVII, p. 89, Pl. II, fig. 9.
 1882. *Phallusia hygomiana* Traustedt, Vidensk. Meddel. natur. For. Kjöbenhavn, ann. 1881, pp. 280, 286, Pl. IV, fig. 7; Pl. V, fig. 18.
 ?1860. *Ascidia* species Stimpson, Amer. Journ. Sci., (2) XXIX, p. 443.
 1891. *Ascidia hygomiana* Herdman, Journ. Linn. Soc. London, Zool., XXIII, p. 594.
 1898. *Ascidia hygomiana* (? + *A. interrupta*) Sluiter, Mém. Soc. Zool. France, XI, p. 6.
 ?1900. *Ascidia* species Wilson, Amer. Naturalist, XXXIV, p. 354.
 1908. *Ascidia hygomiana* Hartmeyer, Year Book Carnegie Inst., Washington, No. 6, p. 111.
 1909-1911. *Phallusia hygomiana* (? + *Ph. interrupta*) Hartmeyer, Bronn's 'Tierreich,' III, suppl., pp. 1402, 1630.

External shape and appearance very variable; form usually rather elongate, the branchial aperture terminal on the somewhat narrowed anterior part of the body, the atrial aperture rather far back (often near the middle of the dorsal border) on a short tube which usually extends out at a considerable angle from the long axis of the body. Body usually considerably compressed laterally; in the more regularly shaped specimens the dorsal, ventral, and posterior borders are thick and rounded, but the body is very liable to distortion, or to irregular depressions, folds, or furrows which often greatly disturb its symmetry and baffle all attempts to give a description which would cover all the variations. Attachment usually by the left ventral region, but individuals vary greatly in this respect. Some of the above irregularities in form and point of attachment are evidently due to the pressure of other individuals, for the species often grows in clumps or groups of individuals of its own or of other species, but in many cases they seem to be merely manifestations of individual variation. Many of the specimens from Fort Macon, North Carolina, are of fairly regular elliptical outline, but as a rule the anterior part of the body is considerably elongated and narrower than the posterior half; this character is still more pronounced on removing the animal from the test, as the latter is proportionally thicker on the anterior half of the body.

Size of the larger specimens usually from 40 to 50 mm. long, and from 20 to 25 mm. in dorso-ventral diameter; the amount of lateral compression is very variable. From Andros Island, Bahamas, there are several that are very large. The three largest measure 105 mm. by 38 mm., 106 mm. by 37 mm., and 77 mm. by 32 mm., respectively. The Porto Rican specimens average small.



Figs. 59-61. *Phallusia hygomiana* Traustedt, 1882

Fig. 59. Left side of body, $\times 3$. Fig. 60. Dorsal tubercle, $\times 10$. Fig. 61. Part of brachial sac, $\times 36$.

Test usually rather thick (thinner in many of the Porto Rican specimens), firm, and rigid in the alcoholic material yet rather easily broken; its outer surface often fairly even but generally not shiny, often having a slightly rough, fibrous texture. It is often discolored by a very thin coating of fine mud, and in old and large specimens it may be somewhat incrustated with calcareous algæ or other foreign bodies, but usually not to any great extent. General color of the test quite variable, most commonly a rather characteristic yellowish gray or yellowish brown, but among the numerous specimens are a few with a smoky bluish cast and others of a pinkish gray. The test has but little transparency; even in

very young individuals it has a cloudy character; in older ones usually little or nothing can be seen through it.

Mantle musculature in most respects rather similar to that of *Ph. nigra* but the greater part of the left side is almost entirely free from muscles; a few longitudinal bands extend back a little way from the anterior end, though in most individuals they do not reach far. On the right side there are a small number of long longitudinal bands and a very much larger number of narrow, irregularly transverse or somewhat oblique bands forming an irregular network.

Tentacles numerous, apparently fully 100 in some individuals. They are of at least four orders and often show considerable regularity in their arrangement.

Dorsal tubercle having a horseshoe-shaped orifice with the open interval turned more or less directly forward, and the horns incurved.

Dorsal lamina with transverse ribs along its left side; the free edge is rolled over to the right and is plain anteriorly and denticulate farther back. It extends a long distance past the œsophageal opening.

Branchial sac usually narrow and tapering in the anterior part. The posterior part extends back a considerable distance beyond the stomach, and is also usually somewhat narrowed, its extreme posterior end being usually truncate or extended into a rather narrow rounded apex, but there is great variation in its shape in different individuals. Intermediate papillæ are wanting, a minute plication of the sac is developed to an extent very similar to the condition in *Ph. nigra*, and the number of stigmata in a mesh (generally from 5 to 10, depending on the amount of plication) is about the same. The transverse vessels are of several orders; the papillæ at the intersections of the transverse and internal longitudinal vessels are, however, narrower and more strongly falciform than in that species. Another difference distinguishing it from *Ph. nigra* is that the alimentary tract is smaller, covering in most individuals a smaller proportion of the left side, though the intestinal loop is bent a little more than in that species and its anteriorly extending loop is opened out a little more. Near the end the rectum often makes an abrupt dorsal bend, conforming to the dorsal direction of the atrial tube. Most of the Bahaman specimens have the part of the intestine between the apex of the anterior loop and the commencement of the rectum greatly distended with mud into a saccular enlargement. Stomach small, its wall with a few obscure plications.

A part of the ovary is visible in the opening of the anteriorly extending loop of the intestine; in some specimens a part of it is also visible in

the other loop near the bend where the intestine turns from a posterior to a dorsal direction. The tubules of the male glands ramify over most of the anteriorly extending loop of the intestine and over the proximal half (or even more) of the oviduct, and over the part of the intestine that the above portion of the oviduct accompanies.

Small renal sacs, each containing a small round brown concretion are also abundantly scattered in the region between the intestine and the adjacent body wall, but in many specimens the small size of the concretions prevents these from being very conspicuous.

This species may be the same as Heller's (1878) *Ascidia interrupta* from Jamaica. If so, his name has priority. Heller's description is, however, too incomplete for certain identification. There is also a possibility that this species is identical with Lesueur's (1823) incompletely described *Ascidia ovalis*, found on a ship's bottom at Philadelphia, doubtless brought from some other more southern locality.

The numerous specimens in the collections I have studied show it to be a common shallow-water species in the West Indian region from North Carolina (Fort Macon near Beaufort, collected by Dr. H. C. Yarrow, specimens in Yale University Museum) to Cuba (Cienfuegos, Cabañas), the Bahamas (Andros Island), and St. Thomas (on piles). It was obtained in great abundance on the piles and stringpieces of the wharves in Guanica Harbor, Porto Rico, by the American Museum expeditions. Most of the specimens were growing in densely crowded clumps and clusters containing several other kinds of ascidians, mussels, worm tubes, etc., besides numbers of its own species, and the individuals were much compressed and distorted, owing to this crowding and pressure. Records for it from the Florida coast include Key West (collected by Prof. A. S. Packard, Yale University Museum) and Cedar Keys (U. S. National Museum). There are no records from Bermuda. There is not any reason to suppose any of the above specimens were from water more than a few feet in depth.

***Phallusia sydneyensis* (Stimpson), 1855**

[*Ascidia sydneyensis* under proposed system of *nomina conservanda*]

Figures 62-65

1855. *Ascidia sydneyensis* Stimpson, Proc. Acad. Sci. Philadelphia, VII, p. 387.
1878. *Ascidia canaliculata* Heller, Sitzungsber. Akad. Wiss. Wien, math.-nat. Kl., LXXVII, p. 84, Pl. I, fig. 1.
1882. *Phallusia longitubis* Traustedt, Vidensk. Meddel. natur. For. Kjöbenhavn, ann. 1882, pp. 283, 286, Pl. iv, figs. 11, 12; Pl. v, figs. 20-22.

1885. *Phallusia longitubis* Traustedt, Vidensk. Meddel. natur. For. Kjöbenhavn, ann. 1884, p. 16.
1891. *Ascidia longitubis* + *A. canaliculata* + *A. sydneyensis* Herdman, Journ. Linn. Soc. London, Zool., XXIII, pp. 593-595.
1894. *Phallusia longitubis* Traustedt and Weltner, Arch. f. Naturgesch., LX, p. 10.
1898. *Ascidia longitubis* Sluiter, Mém. Soc. Zool. France, XI, p. 8, Pl. I, figs. 1, 2.
1899. *Ascidia sydneyensis* Herdman, 'Descr. Cat. Tunicata Australian Mus.,' p. 15.
- 1909-1911. *Phallusia longitubis* + *Ph. canaliculata* + *Ph. sydneyensis*, Hartmeyer, Bronn's 'Tier-reich,' III, suppl., pp. 1402, 1630, etc.
1911. *Phallusia canaliculata* (part) Hartmeyer, 'Deutsch. Südpol.-Exp.,' XII, p. 576.
1918. *Ascidia canaliculata* Michaelsen, Jahrbuch Wiss. Anst., Hamburg, XXXV, suppl. 2, p. 59.
1919. *Ascidia sydneyensis* (part) Hartmeyer, Kungl. Svensk. Vetensk. Akad. Handl., LX, No. 4, p. 98.
1921. *Ascidia canaliculata* Michaelsen, Arkiv för Zoologi, XIII, No. 23, p. 5.

The body is moderately elongate (this being in part due to the large and long branchial tube into which the anterior end tapers) and moderately compressed; the posterior end broad and rather truncate, or slightly rounded. The atrial tube is well developed, situated far back, and is often directed obliquely backward or bent in that direction. Attachment by a considerable part of the left side. Branchial aperture with seven or eight lobes, the atrial with six lobes. Test colorless and quite transparent, of rather firm rigid consistency (in alcoholic specimens at least) and in the specimens at hand it is quite smooth externally and free from incrusting foreign matter. Size of largest individual (from Cabañas, Cuba): total length, 53 mm.; dorso-ventral diameter, 27 mm.; thickness, 12 mm.

The species is most readily recognized by the characteristic musculature of the mantle. The large branchial and atrial tubes have conspicuous and numerous circular muscle bands and a few longitudinal ones. Longitudinal muscles are insignificant elsewhere on the body. The whole left side is nearly free from muscles, the mantle being thin, colorless and transparent. The greater part of the right side is in the same condition, but all around the dorsal, ventral, and posterior margins of the right side there is a wide border of short stout muscle bands extending inward from the margin for a varying distance. They lie for the most part parallel to each other and at right angles to the margin, but curve and cross each other irregularly to a slight extent.

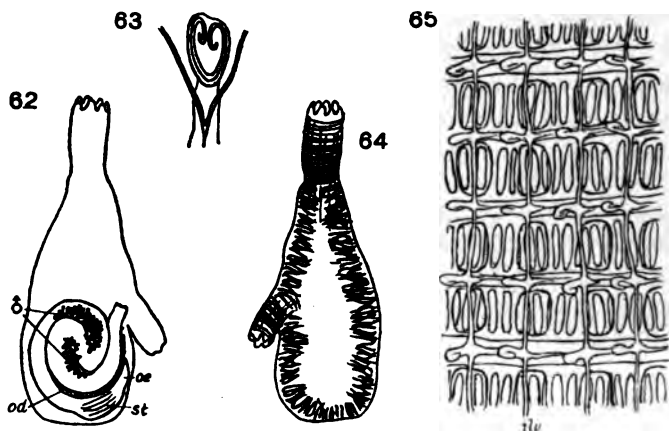
The following notes on the internal structure are based on the larger of the two Porto Rican specimens (see below); they agree sufficiently well with Traustedt's description.

Tentacles numerous, probably 60-70, of several sizes.

Dorsal tubercle heart-shaped, long and very narrow, open interval forward, horns inrolled.

Dorsal lamina with a nearly plain edge rolled over toward the right side. (Sluiter, 1898, mentions and figures a few denticulations on the posterior part.)

Branchial sac not extended much beyond the digestive tract posteriorly, its anterior part narrow, the posterior part broad. Transverse vessels of at least three or four orders, but even the smallest are fairly stout. None of them take any part in the minute plication of the



Figs. 62-65. *Phallusia sydneyensis* (Stimpson), 1855

Fig. 62. Left side of body, $\times 1.6$. Fig. 63. Dorsal tubercle, $\times 12$. Fig. 64. Right side of body showing arrangement of muscles in the mantle, $\times 1.6$. Fig. 65. Part of branchial sac, $\times 42$.

sac which is characteristic of the genus. This plication, therefore, assumes the appearance (when seen from the interior of the sac) of numerous small deep oblong pits or depressions instead of a series of ridges and furrows. Internal longitudinal vessels regular and complete but very delicate. At their intersections with the transverse vessels they bear small, narrow, much bent or hooked papillæ. Intermediate papillæ (between transverse vessels) are wanting. The internal longitudinal vessels are separated by an interval equal in width to four or five stigmata in most places; the intervening number of stigmata is, however, actually greater, owing to the minute plication above mentioned, but it is difficult to determine exactly.

Digestive tract fairly large, covering most of the posterior half of the left side. Stomach rather small, its wall apparently somewhat plicated longitudinally. Intestinal loop large but strongly convoluted into a compact mass so that the parts overlap each other more or less. This is quite different from the condition in *Ph. nigra* and *Ph. hygomiana*.

Reproductive organs almost entirely concealed by the intestine when viewed from the left side. Some of the ramifications of the testes appear upon its surface from between the coils. Of the female organs only the oviduct can be seen; it accompanies the rectum in the usual manner.

This is one of the rarer ascidians of the West Indies and but four specimens have been available for study; two small ones dredged by the American Museum expedition in Guanica Harbor, Porto Rico, 10 to 25 feet, mud, and in Condado Bay, San Juan, Porto Rico, 16 to 22 feet, sand and mud; a large one (see above) from Cabañas, Cuba, and one found on piles at St. Thomas, the two latter in the National Museum collection.

Traustedt described this species from St. Thomas and Crab Island. He reports it also (1885) from Japan. Sluiter (1898) records it from Santa Marta, Colombia; Traustedt and Weltner (1894) report it from Zanzibar. In more recent works (1911, 1919) Hartmeyer identifies Traustedt's species with a widely distributed Pacific and Indian Ocean form that has received several different specific names, *Ph. sydneyensis* (Stimpson), 1855, having the priority and *Ph. canaliculata* (Heller), 1878, being also one of its synonyms. Traustedt's identification of specimens from Japan and Zanzibar with his West Indian species supports this view, which is here adopted, although I have not myself had any opportunity of comparing West Indian and Old World specimens.

***Phallusia curvata* Traustedt, 1882**

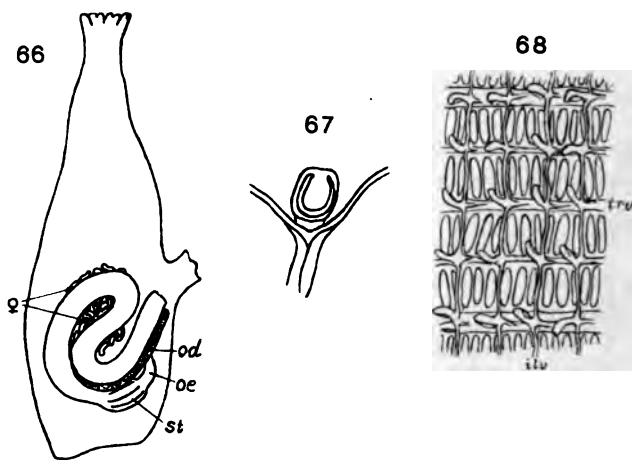
[*Ascidia curvata* under proposed system of *nomina conservanda*]

Figures 66-68

- 1882. *Phallusia curvata* Traustedt, Vidensk. Meddel. natur. For. Kjöbenhavn, ann. 1881, pp. 281, 286, Pl. iv, figs. 8-10; Pl. v, fig. 19.
- 1891. *Ascidia curvata* Herdman, Journ. Linn. Soc. London, Zool., XXIII, p. 592.
- 1898. *Ascidia curvata* Sluiter, Mém. Soc. Zool. France, XI, p. 6.
- 1902. *Ascidia curvata* Van Name, Trans. Conn. Acad. Sci., XI, p. 400, Pl. LVI, figs. 80-82; Pl. LXIII, figs. 145, 146.
- 1908. *Ascidia curvata* Hartmeyer, Year Book Carnegie Inst., Washington, No. 6, p. 111.
- 1909-1911. *Phallusia curvata* Hartmeyer, Bronn's 'Tier-reich,' III, suppl., pp. 1401, 1633.

The following description is based chiefly on specimens collected by the writer at Bermuda.

Body long and narrow, tapering to the branchial aperture at the anterior end and more or less truncate at the posterior end; usually attached by a large part of the left side, the tubes being turned more or less to the right or exposed side. Atrial tube far back, often beyond the middle of the body, usually rather short. Test very thin on attached side, thicker on the other, pale gray or colorless, and sometimes very transparent; markings of light orange-brown about the apertures are present in many living specimens. Some individuals have the external surface smooth and clean; others are wrinkled, or more or less completely cov-



Figs. 66-68. *Phallusia curvata* Traustedt, 1882

Fig. 66. Left side of body, $\times 2.2$. Fig. 67. Dorsal tubercle, $\times 16$. Fig. 68. Part of branchial sac, $\times 42$.

ered with small shell fragments rather loosely adherent or slightly imbedded.

Mantle delicate and transparent. The sphincters of the tubes consist of a number of slender circular bands separated by slight intervals and crossed by some narrow longitudinal bands, which do not however extend much onto the sides of the body. Body musculature weak and mainly confined to the right side, where it consists of a delicate and rather open network of transverse and oblique fibers or very narrow bands crossing each other at various acute angles. These muscles have rather crooked courses. The network is rather denser along the dorsal and

ventral regions, owing to the somewhat stouter and more numerous transverse bands present there, but these do not encroach much if at all upon the left side of the body. Apertures prominently lobed. Length of largest specimen 50 mm.

Tentacles only moderately numerous; of several sizes arranged with some regularity according to the usual scheme. Dorsal tubercle simple, U-shaped or horseshoe-shaped with the open interval forward in the specimens studied.

Dorsal lamina with a toothed margin and conspicuous transverse membranes along its sides.

Branchial sac of a simple type, the small plications or areolations conspicuous in many allied species being comparatively little developed in this form, though not altogether wanting. Transverse vessels of several sizes. Internal longitudinal vessels slender and separated in most places by only three or four, seldom five, stigmata. They bear rather long curved papillæ at their crossings with the transverse vessels. No intermediate papillæ. The branchial sac extends a varying distance posterior to the stomach in different specimens.

Alimentary loop proportionately rather small, and considerably bent, forming a fairly compact mass chiefly or entirely in the posterior half of the body. Stomach small with a few longitudinal plications.

The reproductive organs, both male and female, lie between the branchial sac and the alimentary tract, mostly concealed by the latter, but visible in one of the best preserved specimens along the anterior edge of the anterior loop of the intestine as well as between the branches of the loops formed by the latter. The male glands did not appear to spread over the surface of the intestine next to the branchial sac to any considerable extent in the specimens studied.

This species was described by Traustedt from St. Thomas. I found it one of the commonest simple ascidians at Bermuda in shallow water along the shore, attached to stones, shells, etc. Hartmeyer (1908) reports it from Tortugas, but I have no other records from Florida. The American Museum collection contains a specimen from rocks in San Juan Harbor, Porto Rico.

[NOTE.—*Asciadiella styeloides* (Traustedt), 1882, p. 277, Pl. iv, fig. 5; Pl. v, fig. 16, from St. Croix and St. Thomas, W. I., represents another genus of this family. See p. 483.]

Rhodosomatidae Hartmeyer, 1908

A small but widely distributed and varied family of simple ascidians, characterized (in many cases at least) by the course of the intestine, which bends ventrally after leaving the stomach, instead of dorsally as in most ascidians, thus coming to lie more or less on the right side of the body beside the branchial sac. Internal longitudinal vessels commonly present, though sometimes rudimentary or lost; no large folds in the branchial sac.

RHODOSOMA Ehrenberg, 1828

Anterior of the body modified into a valve or cover which can close upon and protect the apertures. Stigmata straight.

Rhodosoma pellucidum (Stimpson), 1855

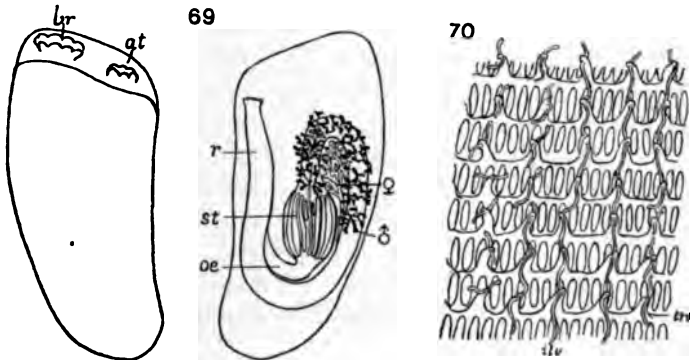
Figures 69 and 70

1855. *Schizascus pellucidus* + *S. papillosus* Stimpson, Proc. Philadelphia Acad. Sci., VIII, p. 377.
1878. *Rhodosoma seminudum* Heller, Sitzungsber. Akad. Wiss. Wien, math.-nat. Kl., LXXVII, p. 91, Pl. I, fig. 5.
1882. *Rhodosoma pyxis* Traustedt, Vidensk. Meddel. natur. For. Kjöbenhavn, ann. 1881, pp. 274, 285; Pl. IV, fig. 4; Pl. V, figs. 15a, 15b.
1885. *Rhodosoma papillosum* Traustedt, Vidensk. Meddel. natur. For. Kjöbenhavn, ann. 1884, p. 9.
1891. *Rhodosoma pyxis* + *R. seminudum* + *R. papillosum* + *R. pellucidum* Herdman, Journ. Linn. Soc. London, Zool., XXIII, p. 598.
1898. *Rhodosoma seminudum* Sluiter, Mém. Soc. Zool. France, XI, p. 10.
1901. *Rhodosoma seminudum* + *R. papillosum* + *R. pellucidum* Hartmeyer, Arch. Naturgesch., suppl., XLVII, pp. 151, 158, 161; Pl. IV, figs. 2, 7, 9-11.
1904. *Rhodosoma seminudum* Sluiter, 'Siboga-Exped.', LVIa, p. 26, Pl. I, fig. 2, Pl. IV, figs. 4-6.
1906. *Rhodosoma seminudum* Hartmeyer, Zool. Anzeiger, XXXI, p. 25.
1906. *Rhodosoma seminudum* Herdman, Rept. Ceylon Pearl Oyster Fisheries, No. 39, suppl., p. 302.
1907. [*Rhodosoma*] *papillosum* Seeliger, Bronn's 'Tier-reich,' III, suppl., p. 1077.
- 1909-1911. *Rhodosoma seminudum* + *R. papillosum* + *R. pellucidum* Hartmeyer, Bronn's 'Tier-reich,' III, suppl., pp. 1390, 1630, 1624, 1645.
1918. *Rhodosoma papillosum* + *R. pellucidum* Van Name, Bull. U. S. Nat. Museum, No. 100, I, p. 113, figs. 68-71.
1919. *Rhodosoma papillosum* Hartmeyer, Kungl. Svensk. Vetensk. Akad. Handl., LX, No. 4, p. 95.

The following description was prepared from a moderately large West Indian specimen.

Body oblong, not much compressed laterally, tapering toward the posterior end and attached to a shell by an area on the posterior part of the right side. Anterior end of body obliquely truncated. Just be-

hind the anterior margin a deep, obliquely transverse cleft partially separates the anterior wall of the body, which thus forms a hinged lid or cover, so that the two edges of the cleft may be brought together or separated. In this cleft the two apertures are situated near together, but the branchial a little nearer the anterior end than the atrial. The former has about eight obscurely defined lobes, and is somewhat more prominent than the atrial, which has but six lobes. Test rather transparent, nearly colorless, as usual in preserved specimens; free from foreign matter and smooth externally, except for numerous minute conical points or projections arising from the surface on the anterior end of the body and in the vicinity of the above-mentioned cleft. (Occasionally the surface is incrustated with foreign matter, or overgrown with other organisms.) Test not very thick, but firm and rigid, particularly



Figs. 69 and 70. *Rhodosoma pellucidum* (Stimpson), 1855
Fig. 69. Left and right sides of the body, $\times 2$. Fig. 70. Part of branchial sac, $\times 38$.

the portion constituting the lid and the margins of the cleft (which are somewhat thickened); the part lining the cleft is softer and quite flexible, permitting the lid to close tightly and entirely conceal the apertures. Size 30 mm. long by 18 mm. wide (near the anterior end). The species attains, however, a length of 50 mm. or more.

Mantle thin and almost devoid of muscles on most parts, except in the vicinity of the tubes and in the portion of the body which serves as a hinge for the lid. Here, at each end of the hinge, is a group of very short, thick bands by which the lid is moved and held closed.

The tentacles and dorsal tubercle were damaged in dissecting out the animal. According to Traustedt (1882) there are about 50 tentacles of three sizes, and the dorsal tubercle is horseshoe-shaped.

Dorsal lamina replaced by a series of rather long, narrow, triangular languets corresponding in number to the transverse vessels.

Branchial sac without folds or minute plications. Transverse vessels very numerous, alternately larger and smaller, but these are not greatly different in size in most parts of the sac. They bear at intervals equal to about four or five stigmata rather broad but thin triangular supporting papillæ which sustain a system of slender internal longitudinal vessels, the latter connecting with the papillæ not quite at their tips, thus leaving the extreme ends of the papillæ to project slightly beyond the internal longitudinal vessels. A narrow membrane connects the bases of adjacent papillæ arising from the same transverse vessel; indeed, the papillæ might be described as large serrations or triangular projections of the border of such a membrane. The system of internal longitudinal vessels is imperfectly developed and interrupted between the supporting papillæ in many parts of the sac, rudiments of the vessels being usually present as blindly ending lateral branches of the papillæ.

Alimentary tract forming a large oblong loop on the right side of the body. As is the rule in this family, the intestine passes the stomach on the ventral, instead of the dorsal, side of the latter. Stomach small, oblong, with about twenty longitudinal folds and a well-marked typhlosole, which can also be traced throughout much of the digestive tract. Intestine slender; rectum long and straight; its aperture distinctly lobed. The intestinal gland surrounds the duodenal part of the intestine for a short distance a little way beyond the stomach; its tubules are very minute and end in small bulbs.

Ovary of branching form situated in the intestinal loop anterior to the stomach. Its duct can be traced along the distal part of the intestine. Testis an extensive ramifying organ, spreading over the part of the intestine lying anterior and ventral to the stomach on the side of the intestine next to the mantle. Its minute branches end in small wedge-shaped or pear-shaped glands similar to those occurring in the genus *Phallusia*.

Having examined a number of specimens of each, I can find no sufficient characters upon which to maintain the West Indian form distinct from Stimpson's species, which is widely distributed in the Malay Region and western Pacific. Stimpson (1855) described two species, *pellucidum* and *papillosum*, from Chinese waters, but, as there is every reason to believe them identical, I employ the name that has page precedence.

In the West Indies it is uncommon, and only single individuals, not groups or clusters, are generally found. Heller's type was from

Jamaica (found with *Phallusia nigra*). Traustedt had specimens from St. Croix and St. Thomas. One specimen from Porto Rico (Condado Bay, San Juan Harbor, 16 to 22 feet, sand and mud) is in the American Museum collection. The National Museum collection has specimens from St. Thomas (piles near the town); from Jamaica; and from Station 2406, Steamer Albatross, off the west coast of Florida (28° 46' N., 84° 49' W., 26 fathoms, coarse sand and coral).

CORELLA Alder and Hancock, 1870

No valve or cover for the apertures. Stigmata arranged in small spirals.

Corella minuta Traustedt, 1882

Figures 71 and 72

1882. *Corella minuta* Traustedt, Vidensk. Meddel. natur. For. Kjöbenhavn, ann. 1881, p. 271, 285, Pl. iv, fig. 1.

1891. *Corella minuta* Herdman, Journ. Linn. Soc. London, Zool., XXIII, p. 588.

1909. *Corella minuta* Hartmeyer, Bronn's 'Tier-reich,' III, suppl., pp. 1393, 1630.

Owing to the poor condition of the material only an incomplete and unsatisfactory description can be given of this species. It is of very delicate structure, with a soft and flexible test which collapses to a shapeless sac in preservation. The mantle and internal parts, moreover, shrink away to a small mass occupying only a fraction of the space within the test, from the inner wall of which they become entirely detached. These difficulties make the original appearance and the correct relation of some of the parts hard to determine but, judging from the material at hand, the normal form of the body is ovate or oblong, obliquely attached by a considerable area on the posterior part of the left side, and more or less produced at the anterior end into a tube or siphon bearing the branchial aperture at its end. The atrial aperture is dorsal, little if at all produced. Both apertures are rather long, oval openings, with the margin scalloped or lobed, but so obscurely that the lobes are difficult to count.

Test thin, flexible, whitish and somewhat transparent, its surface smooth and clean except for numerous wrinkles and folds, many of which, however, are probably caused by shrinking and are not present during life. Size of largest specimen 28 mm. long by 18 mm. in greatest dorso-ventral diameter.

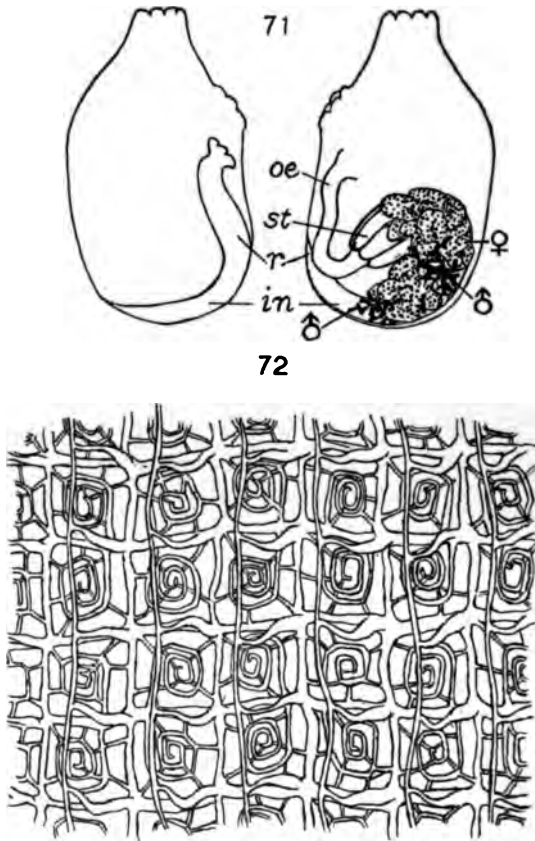
Mantle very thin and transparent, practically free from muscles.

Tentacles long and slender, their number was not determined. (Traustedt gives 26 as the number in the type.)

Dorsal tubercle small, its aperture of simple form.

Dorsal lamina represented by a series of large and rather long and narrow languets.

Branchial sac divided into small square meshes by transverse and longitudinal vessels. In each mesh there is normally a slender spiral vessel making usually from 2 to 4 complete turns. These spirals arise from every alternate transverse vessel. Those which arise opposite each other (extending out from opposite sides of the same transverse vessel)



Figs. 71 and 72. *Corella minuta* Traustedt, 1882

Fig. 71. Left and right side of body, $\times 2.5$. Fig. 72. Part of branchial sac, $\times 45$.

coil in opposite directions. These spiral vessels are not usually raised into conspicuously conical infundibula, but are generally nearly flat. By means of these spiral vessels and a few irregularly distributed radial vessels, the square meshes are subdivided. In addition to the above vessels there is a system of slender internal longitudinal vessels, raised on high, tapering supporting papillæ which arise from the transverse

ssels at their junctions with the external longitudinal vessels. These ternal longitudinal vessels are smooth, without projecting papillæ. the present specimens they appear to be complete and uninterrupted most parts of the sac.

The alimentary tract lies chiefly on the right and posterior aspect of e body (the rectum extends forward on the dorsal aspect, or a little on e left side). The œsophagus is long and curved and opens into the al stomach whose wall has a few deep plications. Extending forward om the stomach, the intestine curves ventrally instead of dorsally as most ascidians, thus passing the stomach on the ventral and posterior de, where it curves forward to form the rather long rectum whose aper- re has a reflexed and distinctly lobed margin.

The ovary forms a broad, flattened layer composed actually of thick anching lobes, but these divisions are so closely crowded when the gan is distended with eggs that the ovary forms an almost continuous eet covering that aspect of the pyloric part of the stomach and of parts the intestinal loop (except the rectum) which lies toward the mantle. e testis is likewise a branching organ; its branches and lobes are rrower and smaller than those of the ovary (at least when the latter well developed), among and between which they ramify.

Nine poorly preserved specimens, most of them very small, were edged by the 'Albatross' at Station 2406 off the West Coast of Florida 8° 46' N., 84° 49' W., 26 fathoms, coarse sand and coral), attached to clcareous worm-tubes, and so forth.

Traustedt's (1882) type of this species was from St. Thomas. He ad but one small specimen. In structure it is close to *Corella borealis* raustedt, 1886, but, as that is an arctic species only once recorded from ty point as far south as Cape Ann, Massachusetts, the two can hardly e identical.

[NOTE.—A larger species (*Corella eumyota* Traustedt, 1882) with uch better developed mantle musculature, widely distributed in the ataretic and subantarctic region, ranges north to Bahia on the eastern uth American coast, according to Traustedt. (See below, p. 483.)]

STOLIDOBANCHIATA Lahille

[= *Ptychobranchia* Seeliger]

The most highly specialized order of ascidians. It contains both compound and ple forms. Body never divided into thorax and abdomen; the digestive tract and productive organs always lie beside the branchial sac, which has internal longitudinal ssels and a few large longitudinal folds or plications (rudimentary or lost in a few nns). Tentacles sometimes compound.

Botryllidæ Verrill, 1871

A small but widely distributed group of compound ascidians, probably to be regarded as degenerate descendants of the same stock as the compound Styelidæ, from which they differ in having systems and common cloacal cavities (not found elsewhere in the Stolidobranchiata). Branchial folds wanting; only three internal longitudinal vessels on each side of the body. Dorsal lamina a continuous membrane.

BOTRYLLUS Gaertner and Pallas, 1774

As here employed, co-extensive with the family Botryllidæ.

Subgenus BOTRYLLUS

Systems small, circular or oval, containing few zooids.

Botryllus schlosseri (Pallas), 1766

Figure 73

- 1766. *Alcyonium schlosseri* Pallas, Elench. Zoophyt., No. 208.
- 1816. *Botryllus schlosseri* Savigny, 'Mém. s. l. animaux sans vertèbres,' pt. 2, p. 200, Pl. xx, fig. 5.
- 1871. *Botryllus gouldii* Verrill, Amer. Journ. Sci., (3) I, pp. 211, 212; figs. 14-19.
- 1873. *Botryllus gouldii* Verrill and Smith, 'Rep. on Invert. animals of Vineyard Sound,' pp. 702, 375, etc., Pl. xxxii, figs. 252, 253.
- 1903. *Botryllus schlosseri* Bancroft, Proc. California Acad. Sci., Zool., (3) III, p. 137, Pl. xvii, figs. 1-3.
- 1910. *Botryllus schlosseri* Van Name, Proc. Boston Soc. Nat. Hist., XXXIV, p. 350, Pl. xxxix, fig. 10, text fig. 1.
- 1915. *Botryllus schlosseri* (*nomen conservandum*) Apstein, Sitzungsab. Gesell. naturf. Freunde, Berlin, ann. 1915, p. 185.
- 1916. *Botryllus schlosseri* Hartmeyer, Sitzungsber. Gesell. naturf. Freunde, Berlin, ann. 1915, p. 252.

For other references and synonyms see Van Name (1910).

This species forms incrusting colonies of variable extent, sometimes several centimeters across, and is subject to many of the same color variations described for *Botryllus niger*, though red or orange varieties do not occur, and the colonies differ from those of that species in having the zooids arranged in small circular or oval systems, usually containing only from five to twenty zooids. The zooids average a little larger and proportionately shorter than in *Botryllus niger*; they have only nine or ten rows of stigmata and the internal longitudinal vessels are separated by about four stigmata. These characters will suffice to distinguish the two species. A more detailed description will be found in Van Name, 1910.

The distribution of this species on the coasts of the Middle and Southern Atlantic States requires further investigation. It is widely distributed on the European coasts and is very common in shallow water

on the shores of southern New England and Long Island, often growing on eel grass. I have no records between New Jersey and Florida, though I cannot suppose it is absent from that part of the coast, as the National Museum collection contains flourishing colonies from Cedar Keys and off Gasparilla Light (7 fathoms) on the west coast of Florida. I failed to find it in my collecting at Bermuda and in southeastern Florida.

73

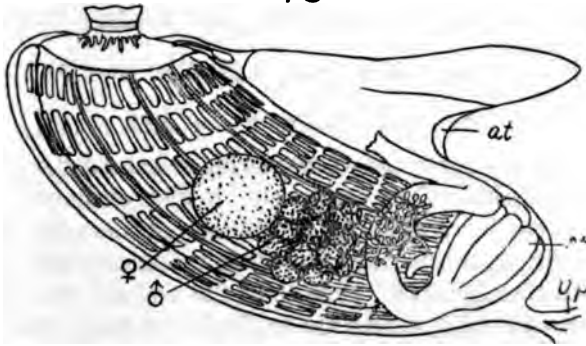


Fig. 73. *Botryllus schlosseri* (Pallas), 1766
Left side of sooid, $\times 45$.

Subgenus **BOTRYLLOIDES** (Milne-Edwards), 1841

Systems more extensive than in the subgenus *Botryllus*, elongate or branching in outline.

Though this group has until lately been almost universally recognized as a genus, the characters separating it are of no more than specific rank, and its recognition as a subgenus can only be justified on the ground of deference to established custom and to avoid the confusion that its sudden entire abandonment might cause.

Botryllus (Botrylloides) niger (Herdman), 1886

Figure 74

1886. *Botrylloides nigrum* Herdman, 'Rep. Voy. Challenger, Zool.,' XIV, p. 50, Pl. I, fig. 8; Pl. III, figs. 19-21.
 1891. *Botrylloides nigrum* Herdman, Journ. Linn. Soc. London, Zool., XXIII, p. 608.
 1897. *Botrylloides nigrum* Sluiter, Zool. Jahrb., Syst., XI, 1897, p. 49.
 ?1898. *Botrylloides chazaliei* Sluiter, Mém. Soc. Zool. France, XI, p. 10.
 1899. *Botrylloides leptum* Herdman, 'Descr. Cat. Tunicata Australian Mus.,' p. 102, Pl. Botr. I, figs. 1-4.
 1902. *Botrylloides nigrum* + varieties Van Name, Trans. Conn. Acad. Sci., XI, pp. 374-378, Pl. LIII, figs. 53-55; Pl. LIX, fig. 110; Pl. LXI, fig. 125.

- ?1906. *Botrylloides nigrum* Herdman, 'Rept. Ceylon Pearl Oyster Fisheries,' V, p. 333, Pl. vii, fig. 25.
- 1909-1911. *Botrylloides nigrum* + varieties Hartmeyer, Bronn's 'Tier-reich,' III, suppl., pp. 1380, 1633, etc.
1912. *Botrylloides nigrum* Hartmeyer, 'Deutsch. Tiefsee-Exp.,' XVI, p. 270, Pl. xli, fig. 10.
1915. [*Botryllus niger*] form *typica* Michaelsen, 'Beitr. Meeresfauna Westafrika,' I, pp. 419, 420.
1916. *Botrylloides nigrum* Pratt, 'Manual Common Invert. Animals,' p. 669.
1918. *Botryllus niger* Michaelsen, Jahrb. Wiss. Anst., Hamburg, XXXV, suppl. 2, p. 45, fig. 6.
1919. *Botryllus niger* Michaelsen, Denk. Akad. Wiss. Wien, XCV, pt. 10, p. 105 fig. 19.
1921. *Botryllus niger* Michaelsen, Arkiv för Zoologi, XIII, No. 23, p. 9.

Colony flat and expanded when growing on extended surfaces; when growing on branching algæ, corals, etc., it may entirely surround the branches. It reaches a diameter of 100 mm. or more (in one case 180 mm); different specimens vary greatly in thickness; some are so thin and flattened that the zooids have to lie flat and are more or less compressed dorso-ventrally, others are so thick and fleshy that the zooids have more than room enough to be placed vertically (at right angles to the surface of the colony). These differences seem to be merely individual or caused by varying conditions of environment, and are without significance in classification. The same is true of variations in color. In preserved specimens the test is usually more or less transparent and nearly colorless or slightly pervaded with a purplish tint, while the zooids and bulbs of the test vessels are some shade of purple, reddish, or brown, sometimes so dark as to be almost black, in other cases very pale. The pigment is in part diffused through the tissues of the zooid, but is chiefly contained in round or oval cells in the mantle, parts of the branchial sac, and bulbs of the test vessels.

In life the colors are much more brilliant. I am familiar chiefly with the color varieties of this species which occur at Bermuda, but in that limited region many very striking and beautiful varieties can be found. Most of them have the zooids of some brown, purple, or blackish shade, as in preserved specimens, but this tint pervades also the test substance to a greater extent than after death. Sometimes the purple shades are replaced by a light bluish gray, but in preservation this changes to purple. In addition to the ground color the zooids are usually marked during life with some light-colored pigment, pure white, pale green, light yellow, or even bright orange, which usually forms a ring or star-shaped area about the branchial orifice. This pigment is likewise contained in

the mantle of the zooids, the bulbs of the test vessels, etc., but, unlike the dark pigment, it disappears almost immediately upon the death of the animal. In a few colonies the zooids were entirely of a bright orange color during life; this color pervaded the test to some extent also. On preservation the zooids in these colonies became a dull reddish, and the test practically colorless. In some specimens the adult zooids exhibit one combination of colors and the immature ones an entirely different

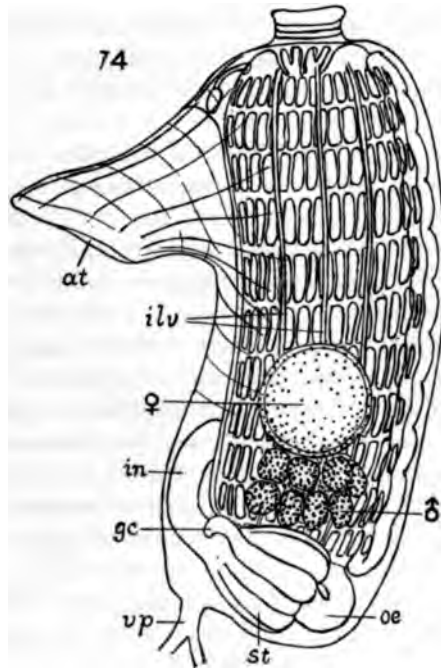


Fig. 74. *Botryllus (Botrylloides) niger* (Herdman), 1886
Left side of zooid, X 40.

combination. Sometimes two colonies entirely different in coloration will be found growing close together, attached to the same object. Several specimens dredged by the Steamer Fish Hawk near Bahia Honda Key in 11 fathoms are in the preserved condition practically without pigment, except for a conspicuous ring (dark purplish brown in the alcoholic material) about the anterior end of the thorax of each zooid.

Zooids small (in contracted preserved material often only 1.5 to 2 mm. long) and arranged in extensive branching systems. In thick

colonies they are usually closely crowded and are placed with their long axes at nearly right angles to the upper and lower surfaces of the colony. In thinner colonies their position is necessarily more or less oblique or, when the colony is very thin, nearly horizontal.

Body of zooid normally of somewhat curved, moderately elongate cylindrical form. Branchial orifice without distinct lobes; the atrial orifice large, situated at the end of a short broad tube which arises from the dorsal side of the body some distance from the anterior end and extends obliquely back. Its anterior lip is often extended to form a large languet. The form, size and position of the tube and orifice are, however, very variable. Mantle musculature moderately developed, especially in the dorsal region.

Tentacles usually of two sizes placed alternately, eight in all. Additional third-order tentacles are sometimes present.

Dorsal lamina plain.

Branchial sac with three internal longitudinal vessels on each side. They are separated by about three stigmata; next to the endostyle and median dorsal vessel there are about five stigmata before the first vessel is reached. Porto Rico specimens have eleven or possibly twelve rows of stigmata; some of the Bermuda specimens appear to have one or two more rows, while in some Florida specimens there are sometimes as many as sixteen rows, though in other specimens only eleven or twelve.

Stomach with nine principal longitudinal folds, one or two small incomplete ones, and a well-developed pyloric cæcum.

A group of small oval testes is present on each side of the body near the posterior end. Directly in front of these there is sometimes a single large egg on each side, or occasionally two. In the older zooids male organs only are found, this species being markedly protogynous (see Michaelsen, 1919, p. 107).

It will be clear from the above description that the specimens assigned to this species exhibit great variation, not only in colors but other characters, including considerable differences in the number of rows of stigmata. Nevertheless, after the study of many specimens from various localities, I have entirely failed to find any tangible basis for dividing them into more than one species. In my account of the Bermuda ascidians (1902), I attempted to give recognition to several of the more striking variations by naming three varieties (*planum*, *concolor*, and *sarcinum*) but, were all the observable differences to be accounted for, it would be necessary to greatly multiply such varieties, and there is no evidence that they represent true races. The variations seem rather to

be individual or due in part to age, stage of growth, and the immediate effect of the conditions under which the colony grows.

This species is common and widely distributed, at least in the northern part of the West Indian region, and occurs both along the shore near low-water mark and on corals, gorgonians, etc., on the reefs and in deeper water to $11\frac{1}{2}$ fathoms (near Bahia Honda Key, Florida) and 21 fathoms (near the northern coast of Yucatan), according to specimens in the National Museum. It is common at Bermuda (the locality of the type, which was obtained by the Challenger Expedition), and at many points on both the east and west coasts of Florida. At Porto Rico, specimens were collected by the American Museum Expedition in Guanica Harbor and east of Caribe Cayo ($5\frac{1}{2}$ to $8\frac{3}{4}$ fathoms) on the south coast, and in Condado Bay, San Juan Harbor, 16 to 22 feet, on the north coast. The National Museum contains a specimen from Green Bay, Bahamas.

It is also widely distributed in the Red Sea, Indian Ocean, Malay region, and Australia (see Michaelsen, 1919, p. 106), and Herdman, 1906, reports a *Botrylloides nigrum* from Ceylon, designating it, however, as a new species, so that it is not clear whether he really intended to refer his specimen here or had forgotten that he had already applied the name *nigrum* to a member of this genus. The very brief description and the illustration he gives shed no light on this question. A variety of this species (variety *magnicæcum*) has also been described by Hartmeyer (1912a, p. 271, Pl. xLi, fig. 11) from the Cape of Good Hope, but is regarded by Michaelsen (1919, 1921) as a distinct species.

Sluiter (1908) described a species, *B. chazaliei* from Margarita Island, Venezuela, which agrees well with the present one in all important characters except the number of internal longitudinal vessels which Sluiter gives as four on each side. This number is often very hard to determine with certainty, unless the zooids are well expanded, and the possibility that *B. chazaliei* is a synonym of the present species does not seem to be excluded.

Styelidæ Sluiter, 1905

[= Tethyidæ Hartmeyer, 1909–1911, not Huntsman, 1912]

A large family found in all parts of the world and including both compound and simple forms. Usually they have both apertures square or four-lobed, simple filiform tentacles, a continuous dorsal lamina and four (or less) longitudinal folds on each side of the branchial sac, which always has straight longitudinal stigmata. The compound forms never have the zooids arranged in systems with common cloacal cavities.

SYMPLEGMA Herdman, 1886[= *Diandrocarpa* Van Name, 1902]

Branchial sac with no folds and only four internal longitudinal vessels on each side. Only one gonad on each side of the body.

Herdman, 1886, described as *Symplegma viride*, new genus and species, a peculiar compound ascidian collected by the Challenger Expedition in shallow water near Bermuda. In spite of the extensive collecting since done in Bermuda waters, no such ascidian has been found again, either there or elsewhere. Michaelsen (1904, pp. 21, 22) offered the suggestion that *Symplegma* and *Diandrocarpa botryllopsi* Van Name, 1902, also from Bermuda, are identical, and made out a strong case in favor of this view. Such a possibility had indeed occurred to me in describing *D. botryllopsi*, but had been dismissed, as the discrepancies between Herdman's description and the real structure of *Diandrocarpa* seemed too great and too numerous to have been overlooked by so experienced an observer as Professor Herdman. Nevertheless, it seems certain that Michaelsen was right and that Herdman's specimen was too poor to give him a correct idea of its structure; the name *Symplegma viride* is accordingly used here instead of *Diandrocarpa botryllopsi*.

Other species and varieties of the genus (see Michaelsen, 1904, 1919; Herdman, 1906) have been since described, showing it to be very widely distributed in the tropical regions; the distinctions separating these additional forms from the Bermuda species and from each other do not, however, appear to be of a kind likely to prove very constant or reliable. (Cf. Michaelsen, 1918, pp. 39, 40; 1919, pp. 104, 105.)

Symplegma viride Herdman, 1886

Figure 75

- 1886. *Symplegma viride* Herdman, 'Rept. Voy. Challenger, Zool.,' XIV, p. 144, Pl. xviii, figs. 7-14.
- 1891. *Symplegma viride* Herdman, Journ. Linn. Soc. London, Zool., XXIII, p. 606.
- 1902. *Diandrocarpa botryllopsi* + *Symplegma viride* Van Name, Trans. Conn. Acad. Sci., XI, p. 383, Pl. LIV, fig. 68; Pl. LIX, figs. 120, 121; Pl. LX, fig. 123; p. 378, Pl. I, fig. 22.
- 1904. *Diandrocarpa botryllopsi* (? + *Symplegma viride*) Michaelsen, Jahrb. Wiss. Anst., Hamburg, XXI, suppl. 2, pp. 21, 22, 42, 43.
- 1907. *Diandrocarpa botryllopsi* + *Symplegma viride* Seeliger, Bronn's 'Tier-reich,' III, suppl., pp. 1132, 1145, text fig. 214.
- 1909-1911. *Diandrocarpa botryllopsi* + *Symplegma viride* Hartmeyer, Bronn's 'Tier-reich,' III, suppl., pp. 1371, 1633.
- 1918. *Symplegma viride* Michaelsen, Jahrb. Wiss. Anst., Hamburg, XXXV, suppl. 2, p. 40.
- 1919. *Symplegma viride* Michaelsen, Denk. Akad. Wiss. Wien, XCV, pt. 10, p. 105.

Colony thin and incrusting, usually not averaging over 2 mm. thick, but sometimes 60 mm. across; commonly of very irregular form, owing to the irregular objects (often branching algæ, corals, etc.) on which it grows. Test transparent and gelatinous in preserved specimens, darker and more opaque in living colonies. Surface of colony somewhat raised over the position of each zooid.

Zooids irregularly scattered, not arranged in systems; each with two independent apertures on the surface of the colony. They lie on their ventral side; the branchial aperture is close to the somewhat up-turned anterior end of the body; the atrial is near the middle of the body. Both have slightly prominent margins, not lobed but sometimes minutely denticulate. Both are elliptical in outline (elongated longitudinally), and the atrial when expanded is much the larger of the two. Size of largest zooids 2.5 to 2.8 mm. long and about 1.3 mm. wide.

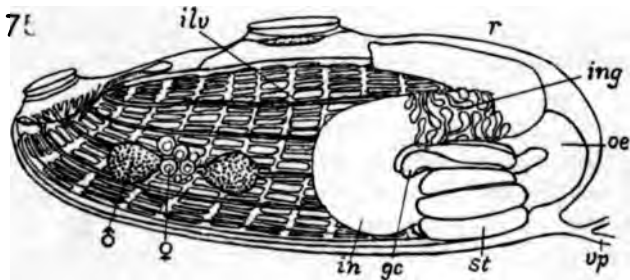


Fig. 75. *Symplegma viride* Herdman, 1886
Left side of zooid (specimen from Bermuda; ovaries poorly developed), $\times 35$.

Zooids oval when seen from above, broad and rounded at the posterior end, narrower in front; blackish, brownish, or purplish, or occasionally olive or greenish in color, due chiefly to pigment cells contained in the mantle and vessels of the branchial sac. During life an area of light-colored pigment, greenish white, pale yellow, or pale salmon, surrounds the branchial aperture. The whole appearance and pigmentation is strongly suggestive of the family Botryllidæ. Branching vessels arising from the posterior ends of the zooids extend through the common test connecting the zooids and end in the marginal regions of the colonies in bulbs containing pigmented corpuscles similar to those occurring in that family.

Mantle musculature slight, chiefly transverse.

Normal number of tentacles apparently 24, of which six are very large; some of the small ones are often rudimentary or wanting. Many minute, slender, atrial tentacles are present.

Dorsal tubercle oval, its opening narrow and elongate.

Dorsal lamina a plain membrane.

Branchial sac without folds. There are four internal longitudinal vessels on each side. Transverse vessels all of one size. Those of opposite sides of the body do not meet the medial dorsal vessel exactly opposite each other. Stigmata in about thirteen rows. About four stigmata intervene between adjacent internal longitudinal vessels. In the meshes along the median dorsal vessel and endostyle there are five or six stigmata, or sometimes more. Branchial sac large and broad, extending nearly to the posterior end of the body.

Stomach and intestine lying chiefly on the left side of the body. Oesophagus short and curved; wall of stomach with rather few (ten to twelve) well-marked longitudinal folds, and a large curved cæcum near the pyloric end. Proximal part of the intestine large, extending forward and dorsally, then posteriorly beside the stomach (this part is surrounded by branching glandular tubules with dilated ends). The intestine then bends abruptly forward to form the rectum, which is of smaller diameter. Margin of anus not lobed.

One gonad on each side; that on the left side farther forward than the other. Each gonad consists of two pear-shaped testes with the small ends near together and an ovary attached to the mantle walls. A short individual duct from each testis unites with that from the other to form a common duct, but it is very short. The ovary, when small, lies between the testes and is bridged over by the sperm ducts. This is a vestige of the condition found in members of this family having more complex gonads, where the individual sperm ducts run on to the inner (free) surface of the ovary and there unite to form a large common sperm duct. No oviduct was demonstrated. When the eggs become large, though they are not very numerous, the ovary spreads over a considerable space on each side of the body. Testes not divided by clefts into lobes or divisions in any of the specimens studied, though a slight notching of their margins, evidently indicating an incipient tendency toward that result, was several times noted. Specimens collected in spring (April and May) have in many cases fairly well-developed testes, but the eggs and ovaries are small.

Locality, Bermuda; common on stones, corals, etc., in shallow water. The typical form has not been recorded from anywhere else, but *S. brakenhielmi* (Michaelsen), 1904 (see below), as well as certain forms from the Red Sea, North Australia, the Indian Ocean, Philippines, etc., appear to be separable from it only as subspecies or varieties, so that the

species as a whole is evidently of very wide distribution in tropical waters (see Michaelsen, 1919, pp. 104, 105).

***Symplegma viride brakenhielmi* (Michaelsen), 1904**

Figure 76

1904. *Diandrocarpa brakenhielmi* Michaelsen, Jahrb. Wiss. Anst., Hamburg, XXI, suppl. 2, p. 50.

1909-1911. *Diandrocarpa brakenhielmi* Hartmeyer, Bronn's 'Tier-reich,' III, suppl., pp. 1371, 1630.

Having examined a considerable amount of material of this genus from Florida and West Indian localities, I find it very variable and believe that there is such complete gradation between the Bermuda and the West Indian forms that the rank of a subspecies is all that can be claimed

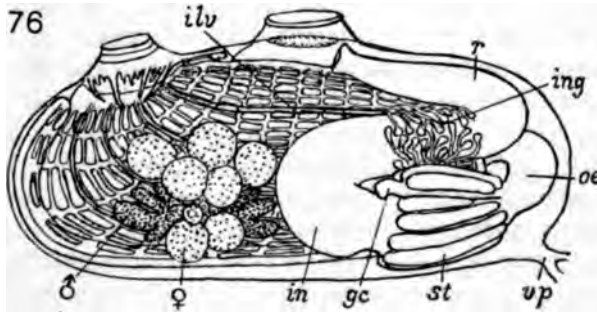


Fig. 76. *Symplegma viride brakenhielmi* (Michaelsen), 1904
Left side of zooid (Individual with developing eggs), $\times 35$.

for the latter, especially as the Bermuda specimens were perhaps not very mature and might later have become more like the West Indian ones. Michaelsen (1919, pp. 104, 105) has arrived independently at a similar conclusion.

As compared with the Bermuda specimens, the colonies are larger (in one case measuring over 90 mm. across) and the zooids reach a larger size (4 mm. or more long); the test is tougher and generally less transparent, and in the preserved material often has, particularly on the parts covering the zooids, a suggestion of a pearly grayish luster, due to the character of its surface, not to any pigmentation. Over the body of each zooid it is more or less raised into a low convex or dome-like elevation, usually separated by a distinct depressed line or furrow from the areas covering adjacent zooids; this causes the surface of the colony to be more or less closely covered with these small raised areas which are of oval

outline (or, where the zooids are close together, often conspicuously polygonal, as a result of this crowding); in each one the two minute, slightly prominent apertures of the zooid appear.

Some colonies have the zooids somewhat more convex and broader in proportion to their length than in the Bermuda specimens, and have the branchial aperture situated a little way back from the anterior end, but there is much variation and no constant difference between the two forms in this respect.

Specimens from Porto Rico and Florida in which the oral tentacles could be accurately observed showed in each case six very large and long ones, of which three were larger than the other three with which they alternated. The extent to which smaller tentacles are present in the intervals between these large ones seems to be subject to much individual variation and of no significance in classification. In the Porto Rico colony two additional orders, bringing the total number up to twenty-four, were present and were quite well developed; in the Florida colony small tentacles were few and rudimentary, though the six large ones were well developed. A circle of numerous, very minute, thread-like atrial tentacles on the edge of a circular membrane or velum at the base of the low conical elevation bearing the atrial aperture were demonstrated in some specimens; there appeared to be some additional more or less rudimentary ones scattered between this circle and the aperture.

A larger number of stigmata than in the Bermuda specimens (up to six or seven between the internal longitudinal vessels and as many as ten or eleven between the dorsal lamina and the first internal longitudinal vessel) were demonstrated in some of the Florida and West Indian material; the number seems in some degree dependent on the size of the zooids.

The number of plications of the stomach wall appears to vary from eleven to fourteen in these specimens (Michaelsen gives the number as fourteen or fifteen).

The material at hand indicates that the gonads may afford a more constant difference, in that the two testes in the present subspecies are each more or less deeply cleft into three to six lobes or divisions, but the extent of such cleavage is very variable and even in the Bermuda specimens a slight notching of the border of the pear-shaped testes evidently indicates a tendency to such a division.

The specimens studied are from Porto Rico (Guanica Harbor in shallow water); the east coast of Jamaica (piles near low-water mark); Biscayne Bay, Florida (banks near Soldier's Key); Tortugas, Florida;

and from localities off the west coast of Florida, in depths down to 27 fathoms.

Michaelsen's type was from Vera Cruz, Mexico. Michaelsen (1904) and Herdman (1906) described varieties of it from the western part of the Indian Ocean and Ceylon respectively, which should now be regarded as varieties of *S. viride* (see above).

POLYANDROCARPA Michaelsen, 1904

Characters practically those of *Polycarpa* (see p. 420), except that it produces buds and forms colonies. Gonads, though small, similar to those of that genus.

Subgenus POLYANDROCARPA

Several or many testes in each gonad.

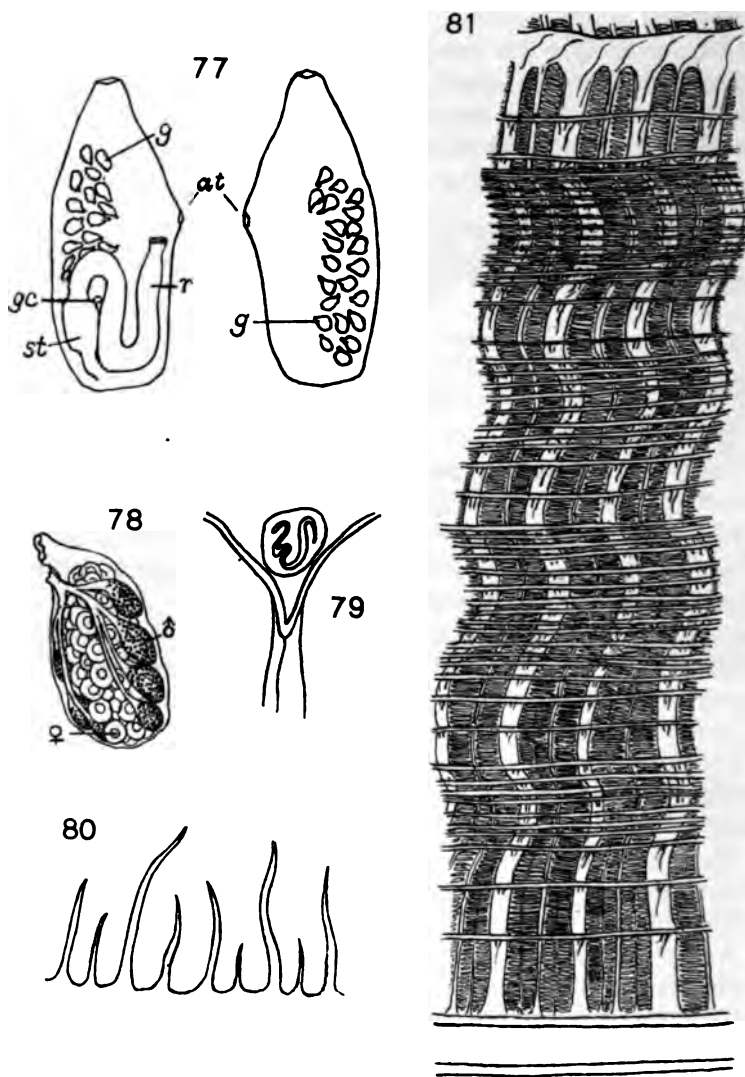
***Polyandrocarpa sabanilla*, new species**

Figures 77-81

Except for the fact that this species grows in irregular groups or clusters which appear to have been formed by budding, it has no characters differentiating it from the genus *Polycarpa*. The individuals are of very irregular, rather elongate form, attached by a large part of the ventral region and more or less closely united to adjacent individuals of the group or colony by a larger or smaller part of the body surface but not so firmly that they cannot usually be torn apart without much injury. The groups or colonies contain only about six to ten individuals (the exact number is not readily distinguishable without separating the individuals), but may have been parts of larger groups. Several separate individuals that were with them were probably originally part of the groups. Vascular connection between individuals was not found and would be difficult to demonstrate on account of the tough, opaque test; it may exist only in the early stages of a colony. Test tough and leathery, opaque, somewhat pearly within, the outer surface rough and wrinkled, of a dirty brownish color, more or less covered with mud and overgrown with foreign matter.

Size of largest individuals about 22 mm. long and 11 mm. in transverse diameter. Though some were considerably smaller than this, all those examined appeared to be adult, having well-developed gonads.

Mantle thick and opaque, its muscles forming continuous sheets or layers. Color light brown, deeper and somewhat purplish about the apertures, which are four sided.



Figs. 77-81. *Polyandrocarpa sabanilla*, new species

Fig. 77. Left and right sides of body, $\times 2.2$. Fig. 78. Gonad, $\times 32$. Fig. 79. Dorsal tubercle, $\times 18$. Fig. 80. Part of the circle of tentacles, $\times 32$. Fig. 81. Part of branchial sac, $\times 24$.

Oral tentacles slender, of about three orders arranged with a moderate degree of regularity. The total normal number appears to be 32. The interior of the low conical projection bearing the atrial aperture is provided at its base with a circular membrane or velum, on which, as well as on the interior of the cone between the velum and the aperture, many very small slender atrial tentacles are irregularly distributed.

Dorsal tubercle large and rounded, but not very prominent. Its orifice is a slit having a different curvature in each specimen examined; some modification of the C or V form seems to be the normal form.

Dorsal lamina a rather narrow, plain-edged membrane.

Branchial sac with four complete folds, of which the first and third are the best developed. Transverse vessels numerous and stout; of three orders (in the ventral region four orders) quite regularly arranged. Small vessels crossing the stigmata are wanting on most parts of the sac. Internal longitudinal vessels numerous but slender, their distribution in a large individual was about as follows:

Left side

dl 2 (17) 2 (9) 3 (15) 3 (8) 2 en

Right side

dl 4 (17) 3 (10) 2 (13) 2 (7) 3 en

On the flat parts of the sac the meshes contain 6 to 10 or more stigmata, the large meshes along the endostyle sometimes 18 to 20 or more.

Digestive tract rather large. Stomach oval and provided with a small pyloric cæcum; its outer surface shows but little indication of plication. The intestine runs forward from the stomach, then backward beside the stomach, then bends forward, forming a rather long rectum. Margin of anus with about ten to twelve rather conspicuously developed lobes. Gonads numerous on each side of the body in the ventral region along near the endostyle. On the left side they are confined to the region not occupied by the alimentary organs. Each gonad is a small oval sac of the usual *Polycarpa* type containing many eggs and a few small, pear-shaped or elongate testes. Many small endocarps are present among the gonads and on the dorso-lateral parts of the body wall.

The specimens (several small groups and some detached individuals) were collected at Sabanilla, Colombia, March 16-22, 1884, by the Steamer Albatross. One of the colonies is attached to a shell. From their condition they appear to have come from a muddy bottom. With them was a specimen of *Microcosmus exasperatus* Heller, 1878. Vascular connection between the individuals of the clusters was not successfully

demonstrated, so that there still remains a possibility that this species belongs in *Polycarpa*. I have not been able to identify it with any of the species of that genus described by Sluiter (1898).

The type is in the U. S. National Museum collection.

***Polyandrocarpa maxima* (Sluiter), 1904**

Figures 82 and 83

1904. *Gynandrocarpa maxima* Sluiter, 'Siboga-Exped.,' LVIa, p. 93, Pl. xv, figs. 5-7.
1909. *Polyandrocarpa maxima* Hartmeyer, Bronn's 'Tier-reich,' III, suppl., pp. 1370, 1644.
1918. *Polyandrocarpa maxima* Van Name, Bull. U. S. Nat. Mus., No. 100, I, p. 103, Pl. xxxi, fig. 33, text figs. 56, 57.

The only specimen forms an irregularly ovoid mass about 18 mm. by 14 mm. in diameter, yellowish white in color in the preserved specimen, but probably red when alive, having a deeply wrinkled and more or less verrucose surface. It resembles a single simple ascidian in appearance except for the more numerous, four-lobed apertures, which, though raised on small papillæ, are not very conspicuous on account of the rough and wrinkled surface. When cut open it is seen to be composed of a dense cluster of four individuals of different sizes (the largest about 11 mm. long) separated only by thin lamellæ of test substance. The test between and close to the bodies of the zooids contains vessels, except where the separating lamella of test is very thin, yet, owing to the tough opaque character of the test, actual vascular connection between the zooids could not be demonstrated. The largest zooid has well-developed gonads and is apparently adult, though perhaps not of the maximum size that may be attained. The following description of the anatomy is chiefly based upon it.

Body oval, not much elongated; both apertures dorsal.

Mantle thin, free from conspicuous muscle bands or pigmentation except on the tubes.

Tentacles about 22, apparently representing three orders; rather irregular in their arrangement, the small ones being wanting in many of the internals.

Dorsal tubercle not demonstrated.

Dorsal lamina a plain, rather narrow membrane.

The branchial sac has four well-developed, though rather low folds, separated by wide flat intervals. Transverse vessels slender and rather widely spaced, so that the stigmata are long. These vessels are of four orders, quite regular in their course and arrangement; the smallest cross, without dividing, the stigmata. Internal longitudinal vessels slender and

rather closely placed, generally separated by four or five stigmata on the flat parts of the sac; even in the largest meshes immediately adjacent to the dorsal lamina and endostyle the number ranges only from about six to nine, rarely ten. Approximate distribution of the internal longitudinal vessels:

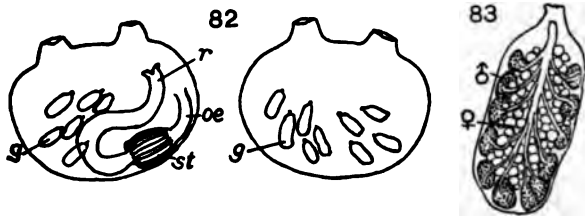
Left side

dl 4 (14) 7 (16) 6 (18) 5 (13) 5 en

Right side

dl 6 (14) 6 (16) 5 (19) 6 (13) 7 en

The rows of stigmata commence close to the dorsal lamina and endostyle.



Figs. 82 and 83. *Polyandrocarpa maxima* (Sluiter), 1904

Fig. 82. Left and right sides of body, $\times 2.6$. Fig. 83. Gonad (side next to branchial sac), $\times 22$.

The alimentary tract forms a rather narrow loop, the oesophagus is long and narrow, the stomach is oval with twenty or more conspicuous plications, the rectum is of moderate length, with a two-lipped, somewhat lobated aperture. Gonads oblong or flask-shaped, of the usual *Polycarpa* type, very loosely attached to the mantle. They are about sixteen in all, irregularly distributed on both sides of the body.

The above-described specimen was from Station 7271, Steamer Fish Hawk (West Channel, entrance to Key West, Florida, $7\frac{1}{4}$ fathoms, coral sand). No differences appear to exist sufficient to separate this specimen specifically from Sluiter's species from the East Indies (Salibabu Island and the Philippines).

Subgenus **EUSYNSTYELA** (Michaelsen), 1904

As this group appears to differ from *Polyandrocarpa* only in the smaller zooids and the reduction of the testes to two in each gonad, the rank of a subgenus of *Polyandrocarpa* seems sufficient for it.

Polyandrocarpa (*Eusynstyela*) *tincta* (Van Name), 1902

Figures 84-86

1902. *Michaelsenia tincta* Van Name, Trans. Conn. Acad. Sci., XI, p. 381, Pl. LV, figs. 61, 63; Pl. LIX, fig. 109.
1904. *Eusynstyela tincta* Michaelsen, Jahrb. Wiss. Anst., Hamburg, XXI, suppl. 2, p. 37.
1907. *Michaelsenia tincta* Seeliger, Bronn's 'Tier-reich,' III, suppl., p. 1147, fig. 215.
- 1909-1911. *Eusynstyela tincta* Hartmeyer, Bronn's 'Tier-reich,' III, suppl., pp. 1370, 1633.
1918. *Eusynstyela tincta* Michaelsen, Jahrb. Wiss. Anst., Hamburg, XXXV, suppl. 2, p. 38.
1919. *Symplegma viride* form *brakenhielmi* Michaelsen, Denk. Akad. Wiss. Wien, XCV, pt. 10, p. 105.
1919. *Eusynstyela tincta* Michaelsen, Denk. Akad. Wiss. Wien, XCVII, pt. 9, p. 96.

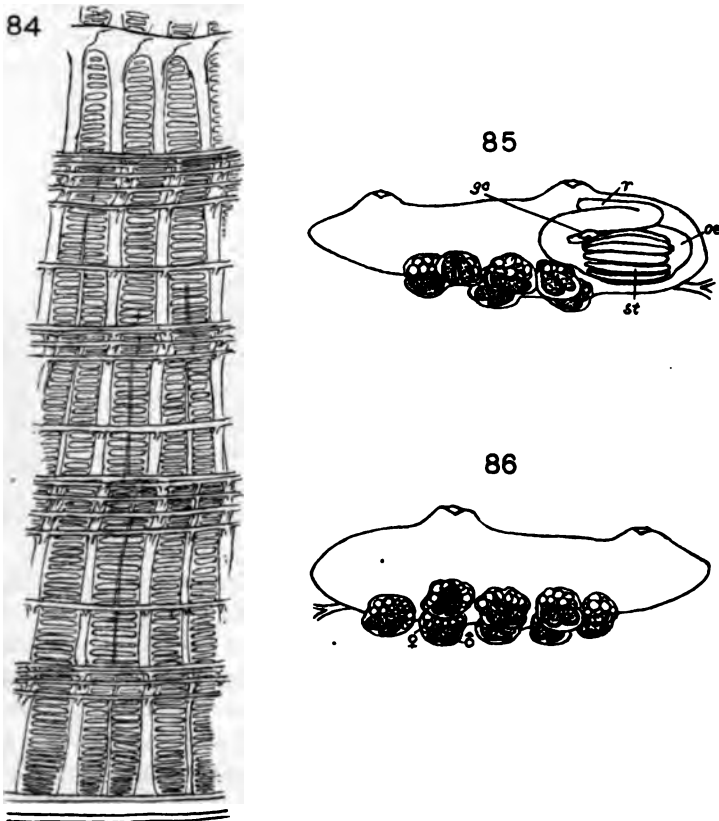
Colony ordinarily of the flattened incrusting type and commonly of small size, often consisting only of from half a dozen to a dozen zooids. Such colonies measure 25 to 35 mm. in greatest thickness and 15 to 20 mm. in greatest diameter; they commonly have a rather thick, rounded border and uneven upper surface. The specimens usually found on stones, etc., along the shore are of this character. It forms, however, under favorable conditions (especially when growing in water a few feet in depth), much more extensive colonies containing one hundred individuals or over. When these grow on some branching object, as a gorgonian, they may entirely surround the branch or two or more adjacent branches and form a much thicker mass of irregular shape, having all or nearly all its surface exposed and bearing zooids on all its aspects, as well as in such clefts or depressions as may exist in its contour. One such colony in the National Museum collection, dredged on the banks off Cedar Keys, Florida, in about 10 fathoms, forms an irregular ovoid mass 55 mm. by 37 mm. by 28 mm. in diameter.

Surface of colony very slightly rough and finely wrinkled; generally the number and position of the zooids is indicated chiefly by the pairs of small rough papillæ on which their apertures are situated.

Test very tough and leathery and very opaque, so that neither the zooids nor the branching vessels which ramify in the test and end in elongate club-shaped bulbs are visible through it. Color of test during life varying from rose pink to carmine red, deepest about the apertures of the zooids, but fading to pink or yellowish in the marginal and basal parts of the colony in many cases. Test substance yellowish in the interior of the colony. The red color soon fades out in preserved material.

Zooids few in most of the colonies and not at all equal in size. In most colonies none of them exceed about 6 mm. long and 2.4 mm. wide,

but the largest may reach 8 or 9 mm. in length. They lie with the ventral surface down, often quite closely crowded together or overlapping each other to some extent, and are strongly flattened dorso-ventrally. Both apertures on the dorsal surface, more or less prominent on the surface of the colony and rather widely separated; the branchial near the anterior



Figs. 84-86. *Polyandrocarpa (Eusynstyela) tincta* (Van Name), 1902

Fig. 84. Part of branchial sac, $\times 45$. Fig. 85. Left side of zooid, $\times 9$. Fig. 86. Right side of zooid, $\times 9$.

end, the atrial behind the middle of the body. Both are square when expanded. The test is roughened and irregularly granular immediately about them in many colonies.

Mantle more or less carmine in color, due to pigment grains contained in its cells. It is not very muscular; the fibers form a thin sheet and are not gathered into bands.

Tentacles numerous (over 30), slender, of at least three sizes. A circle of minute atrial tentacles is present.

Dorsal tubercle oval, orifice generally elongated in an antero-posterior but sometimes in an oblique direction.

Branchial sac with four folds on each side, of which the first and third are the highest. Transverse vessels of two or three sizes. The smallest are generally stout enough to interrupt the stigmata, but in some places they cross them without doing so. Internal longitudinal vessels slender on the folds; those on the flat parts of the sac are thicker. The following scheme shows their distribution in a rather large zooid:

Left side

dl 0 (9) 1 (4) 1 (7) 1 (4) 0 en

Right side

dl 0 (8) 1 (5) 1 (8) 1 (4) 0 en

In the meshes on the flat parts of the sac there are generally about eight stigmata. On the right side the first fold is quite far from the median dorsal vessel, and about fifteen stigmata intervene in some places before the first internal longitudinal vessel is reached. The fold is nearer the median dorsal vessel on the left side. The meshes along the endostyle are also wide, containing often ten or twelve stigmata.

Stomach rather long and narrow with about thirteen or fourteen well-defined longitudinal folds and a small curved pyloric caecum. The stomach is yellow or brown during life. Rectum rather long and straight, its orifice with two well-marked lips, each slightly lobed.

Gonads especially well developed in some of the Florida specimens. Each is a small, rounded sac containing two large, elongate testes and a varying number of eggs. The testes are in the part of the gonad next to the mantle. In most specimens they are of simple, elongate oval form but sometimes one or both of them may be deeply cleft into two lobes. Occasionally there appear to be three or four separate testes in a gonad; that this never occurs it would be unsafe to assert, yet in several such cases a careful examination showed that the appearance was due to a deep lobation of one or both of the two which are normally present.

The gonads are attached to the inside of the mantle of the ventral region in the usual way. They are present on both sides of the body and may form more than one row on each side of the median line. They often project out into the test beyond the general surface of the ventral regions inclosed in small knob-like or rounded evaginations of the body wall, which may be more or less constricted at their connection with the body. Some endocarps are usually present.

At Bermuda, the type locality, this species is found attached to stones at many points along the shore near low-water mark, though nowhere in great abundance. On the Florida coast I have found it in Biscayne Bay on stones along the shores of Ragged Keys, and on calcareous algæ on the banks near Soldier's Key. All the specimens from the above localities were small. The National Museum contains specimens, some of them as mentioned above of considerable size, from deeper water (10½ feet to about 10 fathoms) at stations off the west coast of Florida from the latitude of Cedar Keys to the Bay of Florida. Its distribution may be very much wider, since Michaelsen, 1919, expresses the opinion that *P. (E.) hartmeyeri* from the Red Sea and Mozambique, and *P. (E.) imthurni* from Ceylon are inseparable from it. *P. (E.) latericia* (Sluiter), 1904 of the Malay region he considers another possible synonym. Specimens from the Philippines, which I have referred (Van Name, 1918, p. 105) to *P. (E.) latericia*, differ in certain characters from American specimens, notably in the flatter, more expanded colony, the more numerous vessels of the branchial sac, the smaller number of stigmata (usually only two or three) in the meshes between them, and other minor characters. Although these differences may not prove to be of importance, it would seem better to leave the question open until more information is available.

The type of this species is in the Yale University collection.

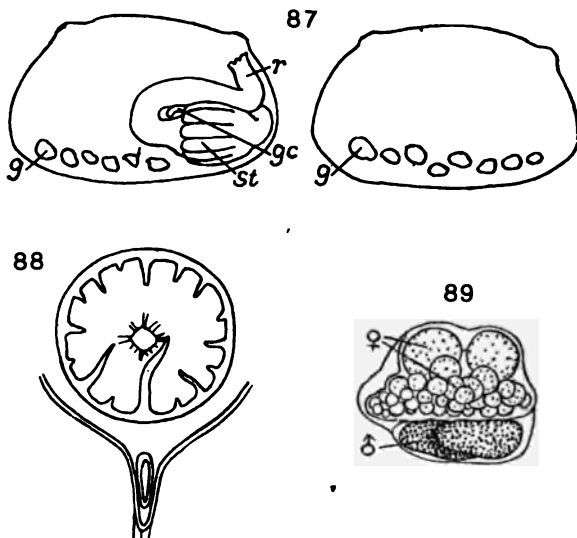
***Polyandrocarpa (Eusynstyela) floridana*, new species**

Figures 87-89

?1852. *Cynthia subcærulea* Stimpson, Proc. Boston Soc. Nat. Hist., IV, p. 231.

Colony diffuse, consisting of many dome-shaped zooids of different sizes, which often lie some distance apart, connected only by a thin sheet or irregular strands of test substance. Zooids of elliptical outline, when seen from above, and sometimes sufficiently convex on the upper surface to form one-half (or even a slightly greater part) of a sphere, but in most cases they are of lower, more flattened form. In some parts of the colony they may lie so close together as to be in contact, but there is always a distinct furrow of demarkation between them and usually they may be easily pulled apart. Size of the largest (type) colony about 55 mm. by 40 mm. across. Test thin, tough, rather opaque, showing a fibrous structure when torn, its outer surface quite smooth. Color in alcohol yellowish white, becoming bluish gray with a slight pearly lustre on the parts covering the zooids; in some places it shows a pinkish or reddish tinge even in the preserved specimens, indicating that the colonies are red or reddish during life.

Zooids covered by a thin, practically smooth layer of test. They lie on their flattened ventral surface; the two apertures are on the dorsal surface quite far apart and both well removed from the ends of the body; they are but very slightly, if at all, prominent in most specimens and are four-sided, though showing in the contracted condition little evidence of this shape. Size of the largest zooids in any of the specimens 8 mm. long by 5 mm. across, but these, though containing some well-developed gonads, may not have reached the maximum size.



Figs. 87-89. *Polyandrocarpa (Eusynstyela) floridana*, new species

Fig. 87. Left and right sides of zooid, $\times 6$. Fig. 88. Circle of tentacles and dorsal tubercle, $\times 32$. Fig. 89. Gonad, $\times 50$.

Mantle thin, musculature slightly developed.

Oral tentacles about sixteen in number, large and smaller alternating, the larger very unequal in size, one or more of those in the posterior part of the circle often especially large and long. Around the inside of the base of the low conical eminence on which the atrial aperture is situated is a circle of very numerous and very minute and slender atrial tentacles. Others are scattered irregularly between this circle and the orifice.

Dorsal tubercle longitudinally elongate, its orifice a similarly elongate slit or cleft.

Dorsal lamina rather wide, with a slightly sinuous edge.

Branchial sac with four folds, of which the first and third are the highest. Transverse vessels numerous, only two orders placed alter-

nately can be recognized in most parts of the sac. Small vessels crossing the stigmata were not noted. Approximate distribution of the internal longitudinal vessels in two rather large zooids:

- (a) Left side
 dl 0 (11) 3 (6) 2 (15) 2 (6) 1 en
 Right side
 dl 2 (11) 2 (6) 2 (16) 2 (6) 1 en
- (b) Left side
 dl 1 (13) 3 (7) 3 (14) 2 (8) 1 en
 Right side
 dl 2 (14) 2 (9) 3 (15) 3 (8) 1 en

The meshes formed by the vessels are small; those on the flat parts of the sac contain (except immediately along the endostyle or dorsallamina) usually only two to four stigmata.

Oesophagus short and curved; stomach short, with about twelve deep plications and a small curved pyloric cæcum. Intestine large; it loops back beside the stomach and then bends abruptly forward and dorsally into a very short rectum whose orifice is very slightly lobed.

Gonads few and small in the specimens studied, attached on the inside of the mantle along each side of the median ventral line. They are small oval or irregular sacs containing a few large eggs and many small ones, and two elongate oval testes. No more than two testes were demonstrated in any of a number of gonads dissected out for careful examination.

The type of this species is from the west coast of Florida (Station 7151, Steamer Fish Hawk, 29°43'40"N., 83°49'45"W., 5¼ fathoms, coral). The remaining specimens, five in number, were dredged in the same region, at some distance off the west coast of Florida from the vicinity of Anclote Keys northward, in depths from 21 to 27 fathoms. Several of them, including the type, were growing on a large simple ascidian, *Polycarpa circumarata*, that is common in that region. It is apparently not a littoral species.

This is a near ally of *P. (E.) tincla*, described above, and *P. (E.) latericia* (Sluiter), 1904, from the Malay Archipelago, but in those forms the colony consists of a thick incrusting sheet of test in which the zooids are deeply imbedded. Superficially, at least, it agrees well with Stimpson's (1852) *Cynthia subcærulea* from Oak Island Beach, North Carolina, but his description is too insufficient to warrant identifying the two in the absence of any specimens of this form from the North Carolina coast.

POLYCARPA Heller, 1877[= *Pandocia auct. mult.*]

Simple ascidians with the characters as given above for the family, having a number of compact sac-like or short tubular hermaphroditic gonads on each side of the body. In the typical species the gonads are small, oval or oblong sacs, and are very numerous.

Polycarpa oblecta Traustedt, 1883

Figure 90

- ?1878. *Polycarpa tumida* Heller, Sitzungsber. Akad. Wiss. Wien, math.-nat. Kl., LXXVII, p. 103, Pl. II, fig. 15.
 1883. *Polycarpa oblecta* Traustedt, Vidensk. Meddel. natur. For. Kjöbenhavn, ann. 1882, pp. 126, 134, Pl. v, figs. 7, 8; Pl. vi, fig. 15.
 1891. *Polycarpa oblecta* (? + *P. tumida*) Herdman, Journ. Linn. Soc. London, Zool., XXIII, p. 584.
 1898. *Styela* (*Polycarpa*) *oblecta* Sluiter, Mém. Soc. Zool. France, XI, p. 11.
 1900. *Polycarpa multiphiala* Verrill, Trans. Conn. Acad. Sci., X, p. 591; idem, 1901, XI, Pl. IX, fig. 7.
 1902. *Polycarpa oblecta* Van Name, Trans. Conn. Acad. Sci., XI, p. 386, Pl. XLVII, figs. 88, 89, 92-94; Pl. LXIII, figs. 140, 144; Pl. LXIV, figs. 151, 153.
 1908. *Polycarpa oblecta* Hartmeyer, Year Book Carnegie Inst., Washington, No. 6, p. 111.
 1909-1911. *Pandocia oblecta* (? + *P. tumida*) Hartmeyer, Bronn's 'Tier-reich,' III, suppl., pp. 1364, 1630, 1633.
 1915. *Polycarpa oblecta* Michaelsen, 'Beitr. Meeresfauna Westafrikas,' I, pp. 412, 413.
 1918. *Pandocia oblecta* Van Name, Bull. U. S. Nat. Mus., No. 100, I, p. 103.

Body rounded-oblong, often with the dorso-ventral diameter exceeding the length; when not distended with water the flexibility of the test permits the sides to collapse so that it is quite narrow from side to side. The apertures, which may be raised on conical elevations, or in contracted specimens may be nearly flush with the external surface, are both conspicuously four-sided; the branchial aperture is situated at or close to the anterior end; the atrial is forward of the middle of the dorsal region. Body usually attached by a small area on the posterior or ventral part of the body, where the test may be produced into a sort of rudimentary peduncle, or may develop some root-like processes or irregular projections to assist in the attachment. Size of the largest specimens studied, about 50 mm. long by 45 mm. in dorso-ventral diameter, exclusive of the short tubes.

Test rather thin except in the dorsal region where it becomes very thick. Color of the outer surface dirty yellowish or brownish gray, usually more or less stained with mud, darkening to red, brown, or

purplish brown about the apertures in fresh specimens. Some individuals have the entire surface or parts of it incrustated with sand and shell fragments, but in a majority of the specimens it is practically bare, fairly smooth in some parts, but with more or less extensive areas which are rough, wrinkled, and warty, or it may even develop patches of short irregular moss-like processes. Other specimens may have the entire surface wrinkled. Internally the test is grayish with a slight pearly cast. Test substance strong, yet soft and flexible when fresh, and even in material long preserved in alcohol it has less tendency to become hard and rigid than in many other allied ascidians.

Mantle smooth and often of a somewhat gelatinous appearance, conspicuously brown in color in most individuals, and provided with a rather weak musculature consisting of longitudinal, transverse, and

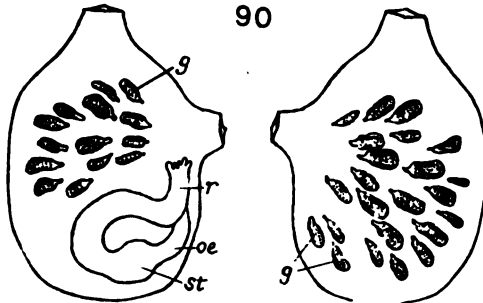


Fig. 90. *Polycarpa oblecta* Traustedt, 1883
Left and right sides of body, natural size.

oblique fibers, of which only the longitudinal ones radiating from the bases of the tubes are gathered into bands of any size. The brown coloration just mentioned pervades many of the internal organs as well as the mantle, and is in part due to granules of pigment in some of the cells.

The tentacles are rather numerous, often forty to sixty in large individuals (55 and 58 respectively were counted in two large specimens) and represent four or more orders in respect to their size and length; only the larger ones show any degree of regularity in their distribution, the small ones being few and irregularly placed.

Dorsal tubercle rather large but not very prominent above the surface of the prebranchial region. It varies in relative size and shape in different individuals, as its orifice does also. The latter is a very narrow cleft usually bent in a C or sometimes an S-shape; in the former case with the open interval forward or more or less to the left and the horns unequally curved (both in, or one in and one out).

Dorsal lamina a plain-edged membrane; endostyle very wide and thick.

Branchial sac peculiar in that many (though not all) individuals have an additional more or less distinct fold on the right side, besides the four which are characteristic of this family of ascidians. This fifth fold lies between the dorsal lamina and the first regular fold and is small, seldom bearing more than three or four internal longitudinal vessels. The remaining folds (as also all those of the left side) are much higher and better developed, bearing from ten to seventeen vessels in the specimens studied, the third fold from the dorsal side (not counting the above-mentioned extra fold) being usually the highest. Although in other families of ascidians the number of folds is variable (sometimes increasing with the age and size of the individual), in the *Styelidæ* the number four on each side is so rarely exceeded as to make such cases of especial interest. Less than four folds, by the reduction and disappearance of one or more of them, are, however, found in many *Styelidæ*.

This extra fold is not morphologically comparable to the other four folds, which must have been inherited from some remote ancestor of the whole family; it may be produced by some secondary cause, possibly largely mechanical in its nature. A peculiarity in the test has been alluded to above. On the sides and ventral part of the body it is very soft and flexible so that the body collapses when the water is expelled from the branchial sac, but over the dorsal part, in the immediate region of the extra fold, it becomes suddenly much thicker and more rigid.

The consequent frequent bending of the body wall at this point may have its bearing upon the development of the extra fold. Why it appears on the right side and not on both is perhaps to be explained by the fact that in this, as in many other members of the *Styelidæ*, the first fold on the left side is usually comparatively close to the dorsal lamina while on the right side there is a much broader flat interval.

Aside from the extra fold, the structure of the branchial sac presents nothing remarkable; the folds are sharply defined and, conformably to the short deep body, very much curved. The transverse vessels are of several orders arranged with a varying degree of regularity; small vessels crossing without dividing the stigmata are not usually present. Internal longitudinal vessels close together on the folds but separated by varying (often rather wide) intervals on the flat parts of the sac. The number of stigmata in the larger meshes is usually from seven to twelve; in the ventral regions of the sac, especially in the meshes along the endostyle, the number is often still greater. Different individuals show some

variation in the number of internal longitudinal vessels, in the regularity of their distribution, and in the number of stigmata that intervene between them. The number of vessels is usually greater in large than in small individuals, but is not altogether dependent on the size. In two large individuals over 50 mm. long, from Florida, the following counts of these vessels were made:

- (a) Left side
 dl 3 (12) 4 (13) 4 (13) 4 (11) 3 en
 Right side
 dl 0 [3] 1 (10) 4 (13) 4 (12) 4 (10) 3 en
- (b) Left side
 dl 3 (14) 3 (13) 3 (14) 4 (12) 3 en
 Right side
 dl 0 [3] 2 (9) 1 (14) 3 (14) 4 (8) 3 en

An individual from Porto Rico, though smaller, has more vessels:

- Left side
 dl 2 (13) 3 (13) 3 (17) 4 (11) 3 en
 Right side
 dl 0 [3] 0 (11) 3 (15) 3 (17) 5 (11) 3 en

An example about 40 mm. long from off the west coast of Florida has still more:

- Left side
 dl 3 (19) 3 (21) 5 (23) 6 (19) 6 en
 Right side
 dl 0 [5] 3 (17) 5 (22) 5 (24) 6 (19) 4 en

Irregularities in the branchial sac, especially in the height of the folds or in the width of the flat intervals, which may be increased at the expense of the adjoining folds, or in the transverse vessels, which may branch or run obliquely, joining an adjacent vessel, are frequent in some individuals; others show great regularity in such details.

Stomach small and short; oval. The intestine forms a small open loop which does not extend much, if at all, forward of the middle of the body. Margin of anus irregularly lobed. A large endocarp connected both with the mantle and the branchial sac is commonly present in the bend of the intestinal loop.

Gonads oblong or flask-shaped, produced into a short neck with the ovarian opening at its end; the opening of the sperm duct is on a small

papilla beside the neck. The number of gonads varies, and is commonly greater in large than in small individuals. In ordinary sized individuals there may be twenty or more on the right side irregularly scattered, but with their necks turned more or less directly toward the base of the atrial tube, while on the left side, where they are confined to the region anterior to the intestinal loop, the number is somewhat less. In very large examples the number on the right side may reach one hundred or more.

As usual in this group of ascidians, the male glands in each gonad are small and often cleft into two or three lobes; they lie against the mantle more or less covered by the ovarian part of the gonad around which their individual sperm ducts curve to join the main branches of the common duct.

Traustedt's type of this species was from St. Thomas, and Hartmeyer (1908) records it from Tortugas, Florida. It is fairly common at Bermuda (see Van Name, 1902, p. 388); one was obtained at Paradones near Cienfuegos, Cuba, by Mr. Barnum Brown of the American Museum, and several were collected by the American Museum expeditions at Porto Rico (Guanica Harbor on piles; one dredged in eighteen feet of water). Those in the National Museum collection, excepting specimens from Eleuthera Island, Bahamas, and Cabañas, Cuba, are from Florida (Tortugas, Key West, and points off the west coast). It ranges from shallow water to a depth of $37\frac{1}{2}$ fathoms, and appears to be commoner in water at least a few feet deep than along the shore.

That this species is distinct from *P. tumida* (Heller), 1878, from Jamaica seems very doubtful, but Heller's description is very incomplete. Among the long list of species of this group that Sluiter (1898) has described from the West Indian region, there appear to be several that are very near to this species, especially *P. friabilis* from Jamaica, *P. brevipedunculata* from Curaçao, and *P. seminuda* from Tortugas Island. It is, therefore, probably of very wide distribution in the West Indian region. *P. arnoldi* (Michaelsen), 1914, from Annobon Island, West Africa, and *P. ovata* Pizon, 1908 (see Van Name, 1918, p. 103) from Amboina, are very close allies, if really distinct from it.

***Polycarpa spongiabilis* Traustedt, 1883**

Figures 91-95

1883. *Polycarpa spongiabilis* Traustedt, Vidensk. Meddel. natur. For. Kjöbenhavn, ann. 1882, pp. 125, 134, Pl. v, fig. 9.
1891. *Polycarpa spongiabilis* Herdman, Journ. Linn. Soc. London, Zool., XXIII, p. 583.

1909-1911. *Pandocia spongiabilis* Hartmeyer, Bronn's 'Tier-reich,' III, suppl., pp. 1364, 1630, 1634.

Though in its internal anatomy this species closely resembles *P. oblecta* just described, I believe that Traustedt was well justified in describing the two as distinct. The sponge-like appearance of the present species readily explains its specific name. It is due to the rough fibrous surface of those parts of the body free from foreign matter, the rigid yet easily broken test and the non-contractile character of the tubes and apertures, which gives them, in the alcoholic specimens at least, a resemblance to the oscula of sponges.

Shape of body very variable in the specimens available for study, which were collected at Porto Rico; strongly compressed from side to side in the small ones, but tumid in the larger ones. Tubes of varying length, mere conical eminences in two of the individuals, large, cylindrical and very long in other cases. Orifices somewhat square, not contracted in any of the specimens. The tubes arise near together on the dorsal part of the body, but curve apart so as to form a widely diverging angle (in one case nearly 180 degrees). Largest specimen 40 mm. long, 35 mm. in dorso-ventral diameter, and about 28 mm. wide, exclusive of the tubes. Color of test yellowish or brownish, becoming reddish or purplish on the tubes.

Test in the alcoholic specimens opaque; its surface rough, uneven and fibrous, but not greatly incrustated with foreign matter on the upper half of the body or on the tubes, though in the two larger specimens some minute bivalve mollusks are imbedded in its substance. Upon the ventral half of the body there may, however, be a tangled growth of hair-like processes to which sand grains, shell fragments, mud, etc., adhere, and which evidently serve to anchor the animal.

The internal structure of two of the specimens, one large and one small immature one, was examined. The mantle and test are adherent in the alcoholic specimens.

Mantle rather thick; brownish in color, with an external layer of transverse and an internal layer of longitudinal fibers.

Tentacles 78 in number of the large specimen, less than 50 in small one; of various sizes down to very minute ones (the latter not very numerous and occurring only here and there). No regularity in the arrangement of the different sizes in most parts of the circle. The tubes in these specimens were exceptionally well expanded, permitting an unusually accurate count of the tentacles, even the very smallest. Had they been more contracted, a considerable number of the smaller

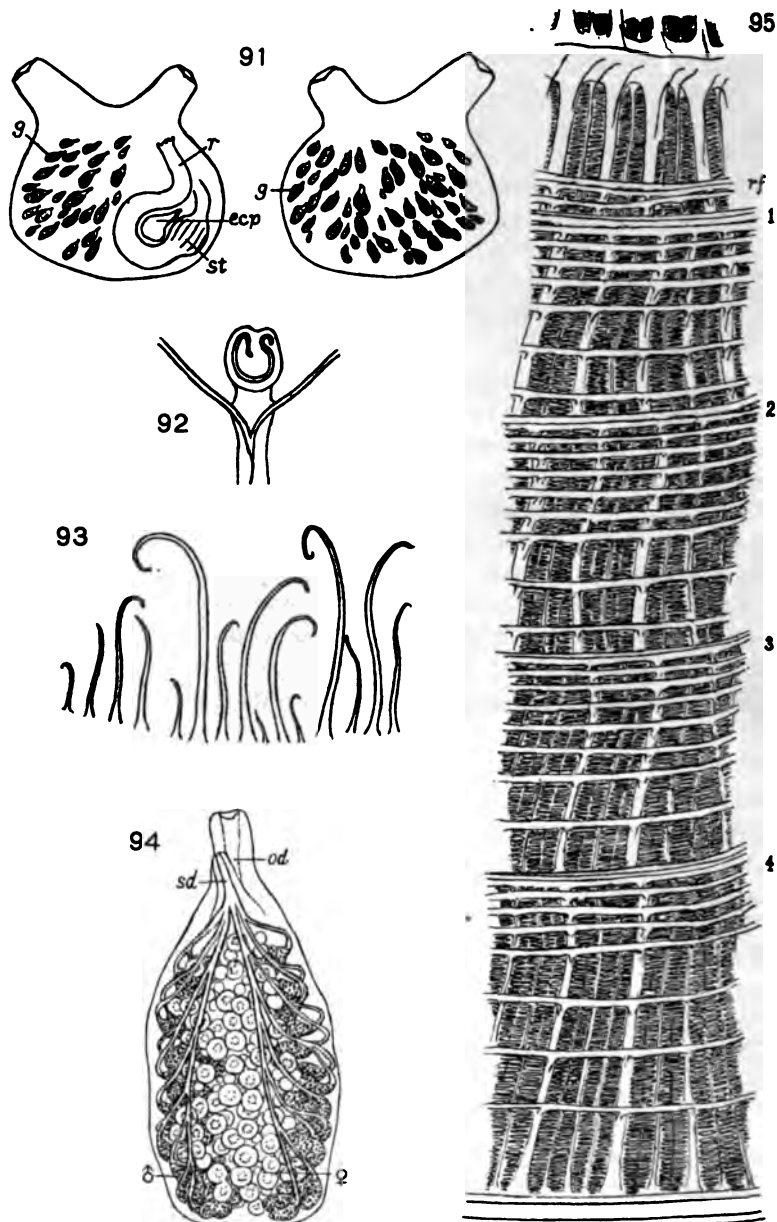
Figs. 91-95. *Polycarpa spongiabilis* Traustedt, 1883

Fig. 91. Left and right sides of body, $\times .75$. Fig. 92. Dorsal tubercle, $\times 12$. Fig. 93. Part of circle of tentacles, $\times 12$. Fig. 94. Gonad, $\times 18$. Fig. 95. Part of branchial sac, $\times 11.5$.

tentacles would doubtless have been overlooked and the number would have seemed lower.

Dorsal tubercle horseshoe-shaped with the open interval forward, both horns bent back, one inward, one outward (both to the left) in each of the two specimens examined.

Dorsal lamina plain, rather narrow.

Branchial sac very similar to that of *P. oblecta*. The rudimentary extra fold on the right side between the dorsal lamina and first true fold is present in the large individual, but not in the small one. Internal longitudinal vessels stout, not very numerous. The four true folds are of variable height in different parts of the sac.

Internal longitudinal vessels distributed approximately as follows:

Left side

dl 1 (11) 2 (14) 2 (15) 3 (12) 4 en

Right side

dl 0 [3] 0 (12) 3 (14) 2 (15) 2 (11) 3 en

Five or even six orders of transverse vessels are recognizable in some parts of the sac. Their distribution is, for the most part, fairly regular; the very smallest, crossing without interrupting the stigmata, are present in some places only. The stigmata are rather long and narrow; owing to irregularities in the distribution of the internal longitudinal vessels on the flat parts of the sac, the number of stigmata in a mesh is very variable, but it is often large, ten to twelve or more in many cases. Along the endostyle and median dorsal vessel there are meshes containing many stigmata (fifteen to twenty or more).

The above description is taken from the branchial sac of the largest individual. That of the small one is similar but there are somewhat fewer internal longitudinal vessels on the folds.

Stomach small, its wall with a few indistinct plications. Intestine forming a small rounded loop. Rectum very short in the small specimen, proportionately longer in the large one. Anus margin with about ten small lobes. In the large individual a large endocarp lies in the bend of the intestinal loop.

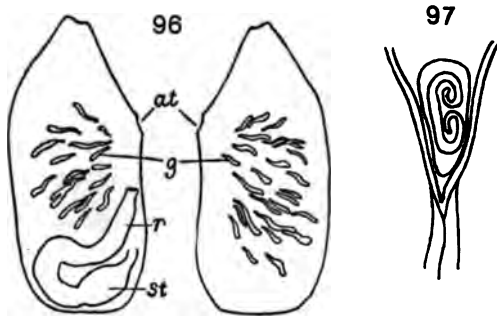
Gonads as in *P. oblecta*. On the right side they number over 50 in the large specimen, and on the left side, where they are confined to the part of the mantle anterior to the intestinal loop, there are about 30. In the small individual the gonads are but poorly developed, though numerous.

Traustedt (1883) gives the localities of his specimens as West Indies and Brazil. A total of six specimens were dredged by the American Museum expeditions at Porto Rico, as follows: entrance to Guanica Harbor, 10–25 feet, mud, 1 specimen; Condado Bay, San Juan Harbor, 16–22 feet, sand and mud, 3 specimens (large); Salinas Cove (east of Parguera) off Don Luis Cayo, 5–4½ fathoms, coral, mud, 2 specimens.

***Polycarpa circumarata* (Sluiter), 1904**

Figures 96 and 97

1904. *Styela circumarata* Sluiter, 'Siboga-Exped.,' LIVa, p. 70, Pl. i, fig. 4; Pl. ix, fig. 1.
 1909. *Pandocia circumarata* Hartmeyer, Bronn's 'Tier-reich,' III, suppl., p. 1363.
 1918. *Pandocia circumarata* Van Name, Bull. U. S. Nat. Mus., No. 100, I, p. 92, fig. 46; Pl. xxvi, figs. 7, 8.



Figs. 96 and 97. *Polycarpa circumarata* (Sluiter), 1904

Fig. 96. Left and right sides of body, natural size. Fig. 97. Dorsal tubercle, $\times 6$.

Though subject to great individual variation in shape and manner of attachment, the body in this species is usually elongate, oblong, somewhat abruptly tapered at the front end and strongly flattened from side to side. It is usually extended at the posterior end or in the posterior ventral region into a very short, broad, laterally compressed peduncle for attachment; this peduncle may break up into, or be replaced by, a number of root-like processes. Less often the body is sessile and directly adherent to the object on which it grows; in a few of the specimens there is no lateral compression of the body.

Test moderately thick, tough and very opaque; its substance white with a pearly lining; the outer surface yellowish brown to brassy yellow in color. Its surface is wrinkled or furrowed; these furrows are rather few and mainly longitudinal in most individuals, being separated by

rounded ridges irregularly broken by short transverse or oblique furrows into small rounded elevations; in some individuals, however, the wrinkles are closer together and mainly transverse. Some have parts of the surface lightly incrustated with foreign matter (sand grains, shell fragments, etc., or compound ascidians), but usually not to any great extent except on the peduncle or the processes into which it branches. Largest individual from the West Indian region 52 mm. long and 40 mm. in dorso-ventral diameter.

Mantle thick and opaque, the muscular layers forming thick continuous sheets. It is light colored, as on the other internal organs also.

Normal number of tentacles apparently 32, representing three orders, but some, especially those of the smallest order, are often poorly developed or wanting in some of the positions where they should occur according to the scheme.

Dorsal tubercle large and elongate; the typical form of its orifice seems to be C-shaped, with the open interval to the left and the horns inrolled, but some irregular variation of this form very often occurs instead of the above typical one.

Dorsal lamina a plain membrane widest in its posterior portion.

Branchial sac with four well-defined and moderately high folds separated by wide flat intervals. Transverse vessels very numerous and close together; in some places five or six orders arranged with some degree of regularity may be recognized. Often, however, the large ones are distributed at irregular intervals separated by a considerable but varying number of small ones which may be fairly uniform in size for considerable distances, except for the occasional presence of still smaller ones that cross without interrupting the stigmata. Internal longitudinal vessels also exceedingly numerous and on the folds very closely crowded; on the flat part of the sac they are usually separated by from five to eight stigmata, except along the endostyle and dorsal lamina, where there are more stigmata in the meshes.

Distribution of the internal longitudinal vessels in a specimen 36 mm. long:

Left side

dl 6 (37) 7 (37) 8 (33) 9 (26) 5 en

Right side

dl 5 (38) 8 (34) 8 (34) 6 (28) 5 en

In one 48 mm. long:

Left side

dl 5 (40) 9 (36) 8 (39) 9 (29) 6 en

Right side

dl 8 (42) 8 (36) 8 (38) 7 (32) 4 en

Oesophagus short; stomach oval, rather short, its exterior surface showing but little plication. No pyloric cæcum. Intestine of large diameter but forming a rather narrow compact loop lying somewhat transversely to the body axis. No very abrupt bend at the beginning of the rectum, which is rather short. Margin of anus with many minute, rather inconspicuous lobes.

Gonads hermaphroditic, small and numerous, irregularly distributed on both sides of the body, but so deeply buried in the tissues of the body wall, and so much less prominent than the numerous small endocarps which arise between them and partially conceal them, that they are readily overlooked. They are elongate or phial-shaped, often irregularly curved, and sometimes forked or branched. They contain a variable number of small, ovoid or pear-shaped testes and many still smaller, rounded eggs.

In spite of the difference of locality, there do not appear to be any characters separating the specimens here described from Sluiter's species from the Philippines, where it is recorded from depths from 16 meters to 20 fathoms.

It is represented in the National Museum collection by about thirty specimens of various sizes, all dredged in the Gulf of Mexico off the west coast of Florida, by the Steamers Albatross and Fish Hawk, at stations from Deadman's Bay to near Sarasota Point, in depths from $5\frac{1}{4}$ to 30 fathoms on sandy and coral bottom. Most of the specimens were obtained at Station 2405 by the Steamer Albatross ($28^{\circ} 45' N.$, $85^{\circ} 02' W.$, 30 fathoms, gray sand and broken coral), where a large number of examples of *P. oblecta* were also dredged. Several of the individuals of this species are partially overgrown with colonies of *Polysandrocarpa floridana*, a new species of compound ascidian.

STYELA Fleming, 1822

Simple ascidians with characters as given above for the family and a small number (often only one or two on each side) of elongate gonads having in the typical species the male glands alongside of but slightly removed from the ovaries.

***Styela partita* (Stimpson), 1852**

Figures 98-101

1852. *Cynthia partita* Stimpson, Proc. Boston Soc. Nat. Hist., IV, p. 231.
1868. *Styela variabilis* Hancock, Journ. Linn. Soc. London, Zool., IX, p. 318.
1873. *Cynthia partita* Verrill and Smith, 'Rept. on Invert. Animals of Vineyard Sound,' pp. 311, 701, etc., Pl. xxxiii, fig. 246.
1877. *Styela canopoides* Heller, Denk. Akad. Wiss. Wien, XXXVII, p. 254, Pl. vi, figs. 1-3.
1878. *Cynthia partita* Coues and Yarrow, Proc. Acad. Nat. Sci. Philadelphia, 1878, p. 304.
1891. *Cynthia partita* + *C. canopoides* + *C. variabilis* + *C. stellifera* Herdman, Journ. Linn. Soc. London, Zool., XXIII, pp. 581, 586.
1898. *Cynthia partita* Bumpus, Science, new series, VIII, p. 853.
1900. *Styela partita* + *S. canopoides* Verrill, Trans. Conn. Acad. Sci., X, pp. 588, 589; idem, 1901, XI, Pl. ix, figs. 8a, 8b, 8c.
1902. *Styela partita* Van Name, Trans. Conn. Acad. Sci., XI, p. 388, Pl. Lv, fig. 69; Pl. Lvi, figs. 76-78; Pl. Lxiv, figs. 147, 149.
1905. *Cynthia (Styela) partita* Conklin, Journ. Acad. Nat. Sci. Philadelphia, (2) XIII, pp. 1-118, Pls. i-xii (Embryology).
1906. *Styela partita* Fernie and Wiseman, Proc. Zool. Soc. London, p. 34, figs. 7, 9.
- 1909-1911. *Tethyum partitum* Hartmeyer, Bronn's 'Tier-reich,' III, suppl., pp. 1359, 1619.
1912. *Tethyum partitum* Hartmeyer, Denk. Akad. Wiss. Wien, math-nat. Kl., LXXXVIII, p. 191.
1912. *Tethyum partitum* Van Name, Proc. Boston Soc. Nat. Hist., XXXIV, p. 556, Pl. Lix, figs. 94, 95; Pl. Lx, fig. 97; Pl. Lxix, fig. 141; Pl. Lxxi, fig. 153; text fig. 32.
1913. *Styela partita* Sumner, Osburn and Cole, Bull. U. S. Bureau of Fisheries, XXXI, pp. 155, 158-160, 729, 730; chart 192.
1913. *Styela partita* + *S. variabilis* Huntsman, Zool. Anzeiger, XLI, pp. 488-490, text figs. 4, 9.
1915. *Styela partita* Michaelsen, 'Beitr. Meeresfauna Westafrikas,' I, pp. 385-388.
1916. *Styela partita* Hartmeyer, Sitzungsber. Gesell. natur. Freunde, Berlin, ann. 1915, pp. 398, 399.
1916. *Styela partita* Pratt, 'Manual Common Invert. Anim.,' p. 666, text fig. 1009.
1918. *Styela partita* Michaelsen, Jahrb. Wiss. Anst., Hamburg, XXXV, suppl. 2, pp. 33, 34, 35.
- For other references and synonyms see Van Name, 1912, p. 556; Hartmeyer, 1912, p. 191.

Form of body largely dependent on whether the animal is attached singly or in a crowded group of several or many individuals. In the former case, the body may be attached by much of the ventral surface and the branchial aperture situated on the dorsal surface slightly back from the anterior end; in the latter case, the body is often attached by only a small area near the posterior end and the branchial aperture is

situated at the anterior end. The atrial aperture is on the dorsal surface rather near the branchial aperture in either case. When so situated as to grow symmetrically, the body is ovoid, smaller at the anterior end and not much compressed laterally; the apertures are on conical papillæ. Body surface more or less rough and wrinkled, and raised into minute irregular elevations. The surface becomes rougher and the furrows coarser and more conspicuous toward the anterior end. On and about the papillæ bearing the apertures, the furrows usually become replaced by rounded wart-like elevations. Color dirty yellowish or grayish brown, more or less tinged during life with red, red-brown, or purplish, especially toward the anterior end and about the apertures, which may exhibit radial white markings; some specimens are red or reddish all over. Test coriaceous, usually of a somewhat fibrous texture, rather thin on the posterior part of the body, thicker on the anterior part.

On the New England coast it reaches a length of 30 mm., but the specimens from southern localities (Florida and Porto Rico) appear to average smaller, rarely exceeding 20 mm. in length.

Mantle thin, its musculature light; the superficial muscles form an almost continuous sheet; the deeper muscles are gathered into imperfect bands radiating from the bases of the tubes.

Tentacles 40 to 50 in large individuals; of several sizes arranged with a varying degree of regularity.

Dorsal tubercle quite variable; of some modification of the U or horseshoe form; the open interval forward or more or less to the left, and one or both of the horns usually incurved but not spirally coiled.

Dorsal lamina plain-edged.

Branchial sac with four folds on each side separated by rather broad flat intervals. The first and third folds are the highest. Transverse vessels slender, of four, in some places five orders, often quite regularly distributed, the smallest crossing without interrupting the stigmata. Internal longitudinal vessels slender, quite close together on the folds, but separated by from five to eight stigmata (near the endostyle by still larger numbers) on the flat intervals between folds. Distribution of the internal longitudinal vessels in a fairly large individual:

Left side

dl 2 (18) 3 (14) 3 (16) 4 (10) 2 en

Right side

dl 4 (17) 4 (13) 4 (15) 4 (8) 2 en

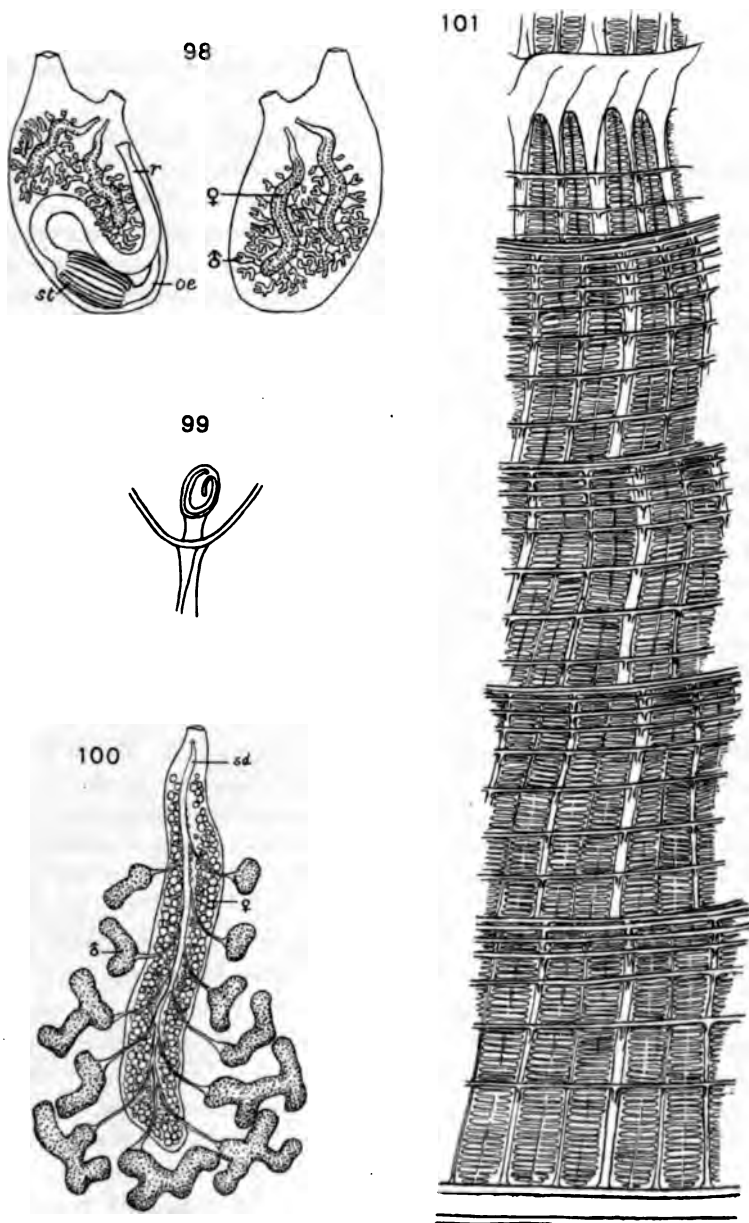
Figs. 98-101. *Styela partita* (Stimpson), 1852

Fig. 98. Left and right sides of body, $\times 2$. Fig. 99. Dorsal tubercle, $\times 12$. Fig. 100. Gonad of a small individual, $\times 20$. Fig. 101. Part of branchial sac, $\times 14$.

Stomach only moderately elongate, its wall with about 20 to 30 longitudinal folds. Margin of anus lobed to a varying extent in different individuals; sometimes merely sinuous.

The best distinguishing character of the species is furnished by the gonads which, owing to the thinness of the mantle, are usually distinctly visible when the animal is removed from its test. There are two on each side, each consisting of a tubular more or less sinuous ovary, narrowed to a neck at its dorsal end, where the opening for the discharge of the eggs is situated. Each ovary is surrounded by a varying number of small male glands which are distributed around the ventral end of the ovary and along its sides, except toward the dorsal end. The male glands lie attached to the mantle a little way removed from the ovary (Fig. 100). Each one, when large, is of elongate and generally irregularly bent form and more or less branched; small ones are of simpler outline. A slender sperm duct leads from each to the unattached surface of the ovary, where those of the several male glands unite to a common sperm duct running along the free surface of the ovary and ending in a papilla beside the neck of the latter. Toward the dorsal ends of the ovaries the male glands become smaller, fewer, and simpler in outline. Often they are wanting entirely along the dorsal half of the ovaries.

This is a well-known and widely distributed form which has been described under several different names. It is a close ally of *S. canopus* Savigny, 1816. On the American coast it ranges from Massachusetts Bay to Florida and the West Indies (Cuba and Porto Rico); on the other side of the Atlantic it ranges from the British Islands to the tropical part of West Africa (specimens in American Museum), including the Cape Verde Islands (Rennie and Wiseman, 1906), and occurs in the Mediterranean and Adriatic. At Bermuda it is represented by a local race (see below). It is an inhabitant of very shallow water, all the material examined being from depths of not more than 15 fathoms.

By the American Museum expeditions to Porto Rico, it was collected from the piles of wharves and mangrove roots in Guanica Harbor, growing in large clumps with mussels, barnacles, bryozoans, ascidians of other species, etc. It was also obtained at Santurce near San Juan, and off Tallaboa Bay where it was dredged in 6 to 11 fathoms (one small specimen). Examples from the South Carolina coast, both coasts of Florida, and from Cuba (Cienfuegos and Las Arroyas) were also in the collections studied.

***Styela partita bermudensis* Van Name, 1902**

1901. *Styela partita* + *S. canopoides* Verrill, Trans. Conn. Acad. Sci., X, pp. 588, 589; XI, Pl. ix, figs. 8a, 8b, 8c.
1902. *Styela partita* variety *bermudensis* Van Name, Trans. Conn. Acad. Sci., XI, p. 388, Pl. lv, figs. 70-75; Pl. lxiii, figs. 142, 143.
- 1909-1911. *Tethyum partitum* variety *bermudense* Hartmeyer, Bronn's 'Tier-reich,' III, suppl., pp. 1359, 1633.

Bermuda specimens of *partita* do not present any differences in internal structure from the typical form. The test is usually thicker and of a more cartilaginous character, and more translucent; the colors are generally brighter, usually a warm brownish yellow or reddish yellow, becoming rich brown or red on the upper surface, especially about the apertures, which may exhibit radial white striping such as sometimes occurs also in the typical variety. These distinguishing characters are certainly not of great importance but, considering its isolated habitat, the form may possibly be worthy of recognition as a geographical race.

The type is in the Yale University collection.

Styela plicata* (Lesueur), 1823*Figures 102-105**

1823. *Ascidia plicata* Lesueur, Journ. Acad. Nat. Sci. Philadelphia, III, p. 5, Pl. iii, fig. b.
1843. *Ascidia plicata* DeKay, 'Zool. New York,' V, 'Mollusca,' p. 259.
1877. *Styela gyrosa* Heller, Sitzungsber. Akad. Wiss. Wien, XXXVII, p. 255, Pl. iii, figs. 7-12; Pl. iv, figs. 1-8.
1881. *Styela gyrosa* Herdman, Proc. Royal Soc. Edinburgh, XI, p. 76.
1882. *Styela gyrosa* Herdman, 'Rep. Voy. Challenger, Zool.,' VI, p. 155.
1883. *Styela plicata* Traustedt, Vidensk. Meddel. natur. For. Kjöbenhavn, ann. 1882, pp. 123, 134, Pl. v, fig. 6; Pl. vi, fig. 16.
1883. *Styela plicata* Traustedt, Mitt. Zool. Stat. Neapel, IV, p. 478, Pl. xxxvi, fig. 12.
1885. *Styela plicata* Traustedt, Vidensk. Meddel. natur. For. Kjöbenhavn, ann. 1884, p. 44.
1891. *Styela plicata* Herdman, Journ. Linn. Soc. London, Zool., XXIII, p. 581.
1900. *Styela plicata* Metcalf, Zool. Jahrbücher, Anat., XIII, p. 516, Pl. xxxvi, figs. 24, 25.
- ?1900. *Styela* species, Wilson, Amer. Naturalist, XXXIV, p. 354.
1905. *Styela plicata* Hartmeyer, Zool. Jahrbücher, Syst., VIII, suppl., p. 384.
- 1909-1911. *Tethyum plicatum* Hartmeyer, Bronn's 'Tier-reich,' III, suppl., pp. 1359, 1630.
1912. *Tethyum plicatum* Hartmeyer, Denk. Akad. Wiss. Wien, math.-nat. Kl., LXXXVIII, p. 192.
1912. *Tethyum plicatum* Van Name, Proc. Boston Soc. Nat. Hist., XXXIV, p. 569, Pl. lxii, figs. 104, 105; Pl. lxiii, fig. 108; Pl. lxviii, fig. 136, text fig. 36.

1912. *Styela plicata*, Huntsman, Contrib. Canadian Biol., p. 149.
1913. *Styela plicata* Huntsman, Zool. Anzeiger, XLI, pp. 489, 497, text fig. 13.
1916. *Styela plicata*, Redikorzew, 'Faune Russ., Tunicata,' part I, p. 197, Pl. v, figs. 1, 2, text figs. 37, 38.
1918. *Styela plicata* Van Name, Bull. U. S. Nat. Mus., No. 100, I, p. 88.
1918. *Styela plicata* Michaelsen, Jahrb. Wiss. Anst., Hamburg, XXXV, suppl. 2, p. 36.

For other synonyms and references see Hartmeyer, 1905.

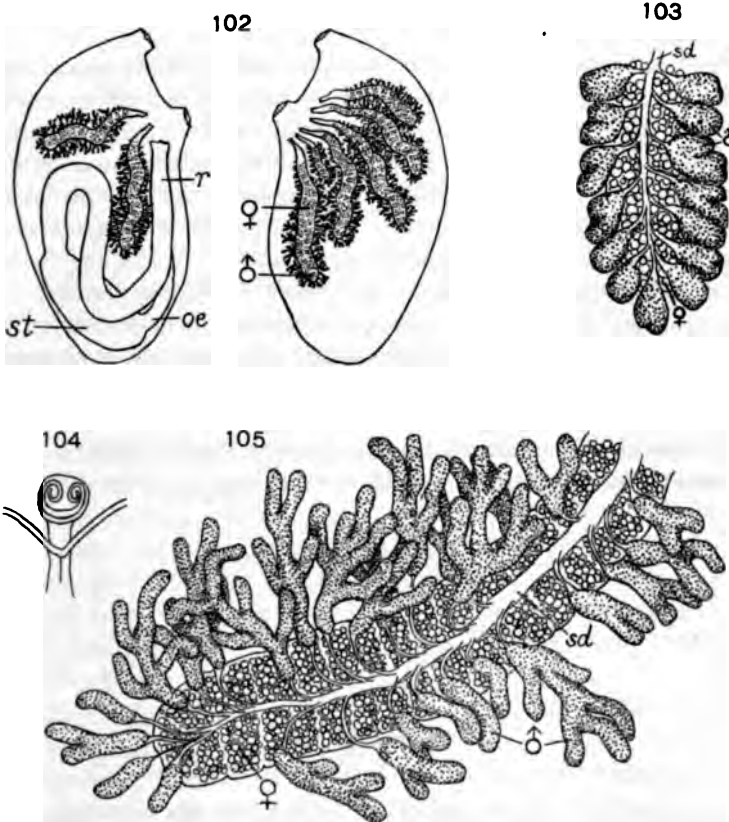
This is a much larger species than *S. partita* and is very variable in external appearance. Sometimes the body is broader in the anterior part or near the middle and narrowed toward the posterior end by which it is attached; the test at this end of the body may be so produced that it may be described as forming a short stout pedicel. Some specimens are strongly compressed laterally, others scarcely at all. In other examples, the general outline of the body is merely oval or rounded and attached by one side or near the posterior end.

The branchial orifice is terminal or nearly so, the atrial a little way back on the dorsal side; both are usually surrounded by four rounded eminences corresponding to the four sides of the square aperture, which lies in the depression between them. In many individuals there is a conspicuous curvature of the long axis of the body by which the apertures are brought towards each other and the ventral side of the body becomes more convex.

The most conspicuous external characters of the species are furnished by the test and the body surface. The test when not discolored is of a dull white color, quite opaque in alcoholic material, but more or less translucent in formaldehyde. It is said to be whitish in living specimens also. Except for a trifling amount of mud, frequently no more than sufficient to discolor the surface, the latter is usually free from foreign matter, though ascidians of the same or other species and other organisms sometimes grow upon it. In some individuals the surface is merely irregularly furrowed; or there are a few conspicuous, rather widely separated furrows whose direction is longitudinal and which are separated by broad, rounded ridges running toward the apertures and ending in the eminences surrounding the latter, which have already been mentioned. In many individuals the ridges are broken, especially in the anterior part of the body, into low but rather large dome-shaped elevations, giving the body surface, or parts of it, an appearance suggesting a coarse unevenly laid cobblestone pavement. Such specimens are very characteristic and easily recognized.

A number of the largest specimens measured ranged from 45 to 72 mm. long and from 25 to 38 mm. in greatest dorso-ventral diameter.

Mantle of only moderate thickness; in some individuals quite thin. The outer layer of muscles encircles the body and its fibers form a nearly continuous sheet. The deeper muscles extend from the tubes toward the



Figs. 102-105. *Styela plicata* (Lesueur), 1823

Fig. 102. Left and right sides of body, slightly enlarged. Fig. 103. Terminal part of a gonad of an individual having the gonada compact and the testes of simple form, $\times 16$. Fig. 104. Dorsal tubercle, $\times 6$. Fig. 105. Terminal part of the gonad of an individual with highly developed branching testes, $\times 12$.

posterior end of the body and are gathered into distinct, rather closely placed bands.

Tentacles difficult to count in the material studied on account of the contraction of the strong sphincter muscles. The number mentioned in Traustedt's (1883) description (25 to 30) seems to be exceeded in many

of the Porto Rican specimens, these apparently having a total of 40 or more, of at least three or four orders, the smaller ones being irregular in their distribution and wanting in many of the intervals.

Dorsal tubercle C-shaped with the open interval forward and the horns strongly inrolled in all the specimens in which this character was studied.

Dorsal lamina plain-edged.

Branchial sac with four quite sharply defined folds separated by rather wide flat intervals. The first three folds do not differ greatly in height and bear over 20 internal longitudinal vessels in most individuals. The ventral fold is somewhat lower. Transverse vessels numerous, of at least five orders in the ventral parts of the sac, the smallest crossing without interrupting the stigmata. They are stout and rather closely placed, and so prominent upon the inner surface of the sac that the meshes containing the stigmata are quite deeply depressed. The presence of two second-order vessels instead of one between two first-order vessels and other similar irregularities may be observed in some parts of the sac in many individuals. Internal longitudinal vessels of rather broad flattened cross-section; they are noticeably stouter on the flat intervals between folds than upon the upper parts of the folds.

Distribution of these vessels in two moderately large individuals:

- | | |
|-----|-------------------------------------|
| | Left side |
| (a) | dl 2 (25) 5 (24) 7 (20) 6 (14) 5 en |
| | Right side |
| | dl 5 (20) 6 (20) 8 (22) 7 (17) 6 en |
| | Left side |
| (b) | dl 2 (22) 6 (20) 5 (22) 4 (19) 3 en |
| | Right side |
| | dl 5 (24) 7 (22) 6 (25) 5 (17) 4 en |

The meshes on the flat portions of the sac between the folds contain, for the most part, from six to nine stigmata.

Stomach large, more elongate than in *S. partita*, its walls with from thirty to forty longitudinal folds, which do not, however, show very conspicuously on the exterior surface. Intestinal loop large but proportionately narrow, its middle part extending back so as to lie beside the stomach. Margin of anus irregularly lobed in some individuals, but only slightly sinuous in others.

Gonads usually two in number on the left side, one anterior to the intestine, the other extending down between the rectum and the descend-

ing part of the intestine. A third gonad on the left side may occasionally be found. On the right side the number of gonads is variable; usually there are from four to seven. They are placed with their necks converging toward the base of the atrial tube. The individual gonads vary greatly in size in the same individual, even when fully mature. Sometimes one or more of them divides into two branches. Specimens obtained at Porto Rico afford excellent material for studying the details of the structure of the gonads and confirm the statement of Huntsman (1913, p. 489) that this species is a typical *Styela* related to *S. partita*. Each gonad consists of a central, elongate, more or less sinuously curved ovary, along each side of which the small male glands are arranged. The sperm ducts follow a similar course to that described above in *S. partita* and the individual male glands have, as in that species, a branching form if well developed. There is, however, this difference in the arrangement: the individual sperm ducts leading from the testes are comparatively short, so that the testes, instead of lying attached to the mantle at a little distance from the ovary, lie close against or more or less upon the latter. The testes are of about the same actual size as in *S. partita* but much more numerous.

Fig. 105 represents part of a gonad of a large specimen in a very well-developed condition. The reader must not expect to find the testes always so numerous or of such elongate and lobate form as in the example there shown. In many specimens, even when the reproductive organs are adult and evidently functional, the testes are merely small oval glands not much divided into lobes, lying close upon and against or even more or less imbedded in the ovary (see Fig. 103). All intermediate conditions will also be found.

This is a well-known species, widely distributed on the coasts of the warmer parts of the Atlantic, Pacific, and Indian Oceans, including the Mediterranean. Lesueur's type specimen was from Philadelphia from the bottom of a ship that must doubtless have come from some more southern port, as the water at Philadelphia is too fresh for it, and there, are moreover, no other records from the American coast north of Fort Macon, near Beaufort, North Carolina. From there it ranges through Florida (where it is very common on the west coast) and the West Indies (St. Thomas, St. Croix, St. Vincent, Cuba, and Porto Rico) to Rio Janeiro and Montevideo (Traustedt, 1883). It is a shallow-water species; in Guanica Harbor it was found abundantly on wharf piles in clusters containing other ascidians as well. The greatest depth recorded for any of the specimens I have examined is 15 fathoms (off the South Carolina

coast). Wilson (1900) reports a large *Styela*, "doubtless *Cynthia vittata* of Stimpson's list," from Beaufort, North Carolina. The number of branchial folds given by Stimpson shows that *C. vittata* Stimpson is not a *Styela*. Wilson's species, if a *Styela*, was probably the present one.

I am now able to extend the recorded range of this species to Bermuda on the basis of a specimen in the National Museum collected at Hamilton in 1882.

***Styela (Botryorchis) atlantica* (Van Name), 1912**

Figure 106

1885. *Cynthia partita* ("apparently") Verrill, Rept. U. S. Comm. Fish and Fisheries for 1883, p. 529.
 1912. *Tethyum atlanticum*, Van Name, Proc. Boston Soc. Nat. Hist., XXXIV, p. 552, Pl. LIX, figs. 92, 93; Pl. LX, fig. 96; Pl. LXVIII, fig. 135, text fig. 31.
 1913. *Botryorchis atlanticus* Huntsman, Zool. Anzeiger, XLI, pp. 498, 499, text fig. 4.

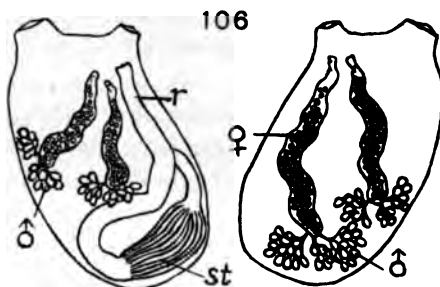


Fig. 106. *Styela atlantica* (Van Name), 1912
 Left and right sides of body, $\times 1.3$.

This species much resembles *Styela partita* in external characters, but averages larger, often 40 mm. or more in length, and has a rougher, more deeply wrinkled test. In internal structure it is distinguished from that species by the very much more numerous internal longitudinal vessels, these being sometimes 40 on a fold and 10 or more on some of the flat intervals; also by the arrangement of the gonads. The ovaries, numbering two on each side, are similar to those of *S. partita*, but the male glands are small, rounded or pyriform bodies, forming several compact clusters grouped around the dorsal or ventral ends of the ovaries, instead of arranged along a considerable part of the sides of the latter.

Other details given in the original description will not be repeated here, as this species is only known from moderately deep water (62 to 397 fathoms) far off the coast of southern New England and the Middle States, chiefly between 38° and 40' N., and 69° and 73° W.

It has been made the type of a genus (*Botryorchis*) by Huntsman (1913) but, while his group is a natural one, the rank of a section of *Styela* would seem sufficient recognition to give it on account of the small differences distinguishing it from the more typical members of that genus.

For further particulars see Van Name, 1912. Additional stations for this species not recorded in that article are:

Station 2198, Steamer Albatross (39° 56' 30'' N., 69° 43' 20'' W., 84 fathoms, sand and broken shells) and

Station 2031, Steamer Albatross (39° 29' N., 72° 19' 55'' W., 74 fathoms, gray mud and black and white sand).

Pyuridæ Hartmeyer, 1908

[=CYNTHIIDÆ, HALOCYNTHIIDÆ *auct. plur.* and TETHYIDÆ Huntsman, 1912]

Simple ascidians having the branchial sac with longitudinal folds (usually five to eight or more on each side) and generally with compound tentacles and straight stigmata. No kidney. Dorsal lamina variable, usually replaced by a row of languets.

Tethyum Bohadsch, 1761

[Proposed *nomen conservandum*, *Halocynthia*]

In the most recent classification this is restricted to those species of the former genus *Halocynthia* having the gonads with several separate, more or less parallel flask-shaped ovaries, the external body surface more or less minutely spiny, and the stigmata longitudinal. Dorsal lamina replaced by a row of languets.

Tethyum microspinosum, new species

(*Halocynthia microspinosus* under proposed system of *nomina conservanda*)

Figures 107-111

The following description is based on only one specimen.

Body irregularly oval, not much compressed laterally, somewhat contracted in the ventral region where it is attached by a small area to a piece of coralline; the apertures, both four-lobed, are widely separated (8 mm. apart), both situated on the dorsal aspect, and scarcely prominent on the external surface. Dimensions 17 mm. long, 17 mm. in dorso-ventral diameter, 9 mm. from side to side. Test yellowish brown, opaque,

its surface free from adherent matter, but uneven with many small and low, rounded elevations, scarcely prominent enough to be termed papillæ except on the dorsal region, where they become small wart-like prominences about 2 mm. in diameter and nearly as much in height in some cases. Everywhere the test is covered with spiny projections so minute as to be visible only on magnification. They are short and stiff and taper to a sharp point, giving the surface a rough, coarse, velvety appearance; about the apertures there are larger ones that bear a few lateral branches, also pointed, but these are very short. In many places these minute spines arise from the surface in small circular tufts of about half dozen; they are not, however, borne on regular rounded elevations as in the case of the allied species *T. pyriforme* Rathke, 1806, of arctic waters. These tufts have no central or axial spine, and in some

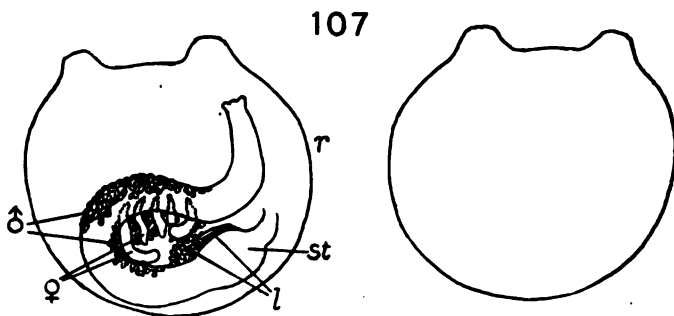


Fig. 107. *Telhyum microspinosum*, new species
Right and left sides of body, $\times 3.2$.

cases, particularly on the papillæ of the dorsal region, they are raised on a short, thick pedicel, from whose summit they radiate out like the tentacles of a minute actinian. It must be understood that all these spines, with the exception of the larger branched ones about the apertures, which attain in a few cases a length of nearly 1 mm., are exceedingly minute. At the inner margin of the apertures the large spines cease abruptly, and are replaced by small, simple, appressed, sharp thorns with the point directed outward, which cover the test lining the distal part of the tubes. These decrease in size from the outer toward the inner end of the tube.

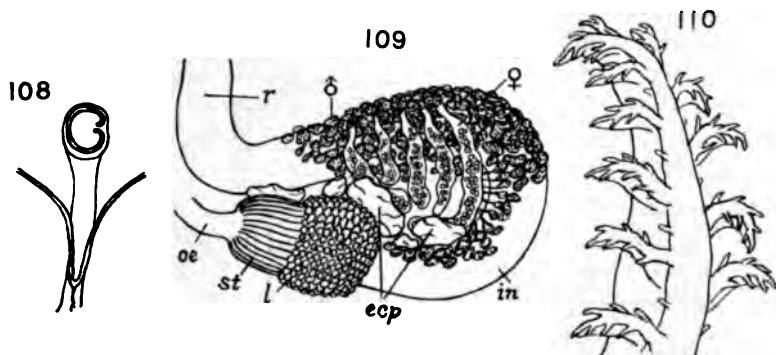
Mantle rather thin; many strong muscle bands extend down on the side of the body from the base of the tubes, those from the two tubes crossing each other on the sides to form a network with small, nearly square meshes. This network is crossed by an external loosely formed

layer of slender fibers, not gathered into very well-defined bands, whose direction is mainly longitudinal.

Tentacles rather few; the large ones number about 12 and are twice pinnate; the branches are rather few and short, their tips not enlarged; smaller sizes of tentacles are also present but are not numerous.

Dorsal tubercle C-shaped, the open interval narrow and directed toward the left; the horns are incurved but not inrolled.

Dorsal lamina replaced by a series of narrow languets.



Figs. 108-110. *Tethyum microspinosum*, new species

Fig. 108. Dorsal tubercle, $\times 16$. Fig. 109. Intestinal loop and gonads seen from side next to branchial sac, $\times 5$. Fig. 110. One of the larger tentacles, $\times 25$.

Branchial sac of very delicate structure, with nine folds on each side. Folds very high, bearing numerous very thin internal longitudinal vessels, the folds are separated by narrow, flat intervals which they entirely conceal when lying flat. Transverse vessels of four or five orders quite regularly placed. Internal longitudinal vessels distributed about as in the following scheme:

Right side

dl 2 (15) 2 (21) 2 (24) 3 (25) 3 (23) 3 (21) 3 (18) 3 (16) 2 (12) 1 en

In this, when a vessel is at the base of a fold, it has been counted as belonging to the fold, not to the flat part of the sac. There are many cases where either course would seem equally well justified. On the left side the arrangement is similar except for the last fold, which is much reduced and bears but few vessels. There are about eight or nine stigmata in the larger meshes on the flat parts of the sac. The stigmata are crossed in most places, without being interrupted, by very minute transverse vessels.

Digestive tract forming a rather small but fairly wide loop; the distal branch bends down so as to nearly touch the stomach, then turns

abruptly dorsally, forming a rather short rectum ending in an inconspicuously lobed aperture; oesophagus short and curved; stomach short; on the aspect toward the branchial sac it bears an extensive hepatic organ consisting of about 25 leaf-like longitudinal folds. On the pyloric part of the stomach these folds are plain-edged; on the cardiac half of the stomach their projecting edges bear small papilla-like or short tubular projections. The organ has thus a very different appearance on the two parts of the stomach.

Gonads very well developed on the left side but wanting on the right side of the body. Whether their absence there is a normal character or merely an individual peculiarity cannot be determined until more specimens are available. In view of the close correspondence of the animal to the other species of the genus *Tethyum*, which have gonads on both sides, I am not inclined to attribute too much importance to their absence in this form, even should it prove to be a normal character of the species.¹ In this specimen there are five crooked tubular or flask-shaped ovaries whose blind ventral ends lie within the intestinal loop; their dorsal ends leave the mantle and lie across and attached to the distal branch of the intestinal loop on the inner aspect of the latter, that is, on the side toward the branchial sac. The testes are very numerous. They are small, oval or pear-shaped, or in some cases lobed or branched bodies; they lie between the ovaries and spread also over the adjacent parts of the intestinal loop, some of them extending around to the external aspect of the intestine (the side next to the mantle). There are several small endocarps in the area inclosed by the intestinal loop.

The type and only example in the collection (Cat. No. 305, Amer. Mus. Nat. Hist.) was found in a jar with a mixed lot of specimens of various classes or animals. No locality was recorded, but from other material in the jar it seems most probable that all the specimens in the lot came from Andros Island, Bahamas. Under these circumstances, it can be only doubtfully included in the West Indian list, although the presence of a member of this genus (*T. papillosum* Linnæus, 1767) in the Mediterranean and another, *T. spinosum* (Sluiter), 1905, in the Red Sea, would seem to render its representation in the West Indies probable.

It is not impossible, in view of their close correspondence in many characters, and of the several species common to the Red Sea and the West Indies, that are already known, that this species may prove to be identical with the above-mentioned one from the Red Sea, but until

¹Michaelsen, 1919, p. 20 records a similar instance in the Red Sea species.



Fig. 111. *Tethyum microspinosum* new species
Part of branchial sac, $\times 10$.

Fig. 112. *Pyura vittata* (Stimpson), 1852
Part of branchial sac, $\times 7.5$.

more material becomes available, that question cannot be definitely decided (see Michaelsen, 1919, p. 10, for description of *T. spinosum*).

Pyura, Molina, 1782

[= *Cynthia* s. *Halocynthia* (part) *auct. plur.*]

This is the largest genus of the family, separable from *Tethyum* by the elongate, longitudinally placed gonads, usually one (less often two) on each side of the body. Dorsal lamina replaced by a row of languets. External body surface rough but usually not spiny.

Pyura vittata (Stimpson), 1852

Figures 112-122

- 1852. *Cynthia vittata* Stimpson, Proc. Boston Soc. Nat. Hist., IV, p. 230.
- 1860. *Cynthia vittata* Stimpson, Amer. Journ. Sci., (2) XXIX, p. 443.
- 1878. *Cynthia lævigata* Heller, Sitzungsber. Akad. Wiss. Wien, math.-nat. Kl., LXXVII, p. 93, Pl. II, fig. 11.
- 1883. *Cynthia riiseana* Traustedt, Vidensk. Meddel. natur. For. Kjöbenhavn, ann. 1882, pp. 118, 132, Pl. v, fig. 13; Pl. vi, fig. 19.
- 1891. *Cynthia lævigata* + *C. riisiana* Herdman, Journ. Linn. Soc. London, Zool., XXIII, p. 577.
- 1898. *Cynthia lævigata* (?) Sluiter, Mém. Soc. Zool. France, XI, p. 20, Pl. II, fig. 24.
- 1900. *Halocynthia rubilabia* + *H. riiseana* Verrill, Trans. Conn. Acad. Sci., X, pp. 589, 590, fig. 7.
- 1902. *Halocynthia rubilabia* + *H. riiseana* variety *munita* Van Name, Trans. Conn. Acad. Sci., XI, pp. 393, 394, Pl. LVI, figs. 83, 84; Pl. LVII, figs. 85-87, 90; Pl. LXII, fig. 133; Pl. LXIII, fig. 141; Pl. LXIV, figs. 150, 152.
- 1906. *Halocynthia rubilabia* Rennie and Wiseman, Proc. Zool. Soc. London, ann. 1906, p. 404, Pl. LXIV, figs. 1-6, 8.
- 1908. *Halocynthia riiseana* Hartmeyer, Year Book Carnegie Inst., Washington, VI, p. 111.
- 1909-1911. *Pyura lævigata* + *P. riiseana* + *P. rubilabia* Hartmeyer, Bronn's 'Tierreich,' III, suppl., pp. 1340-1342, 1629, 1633.

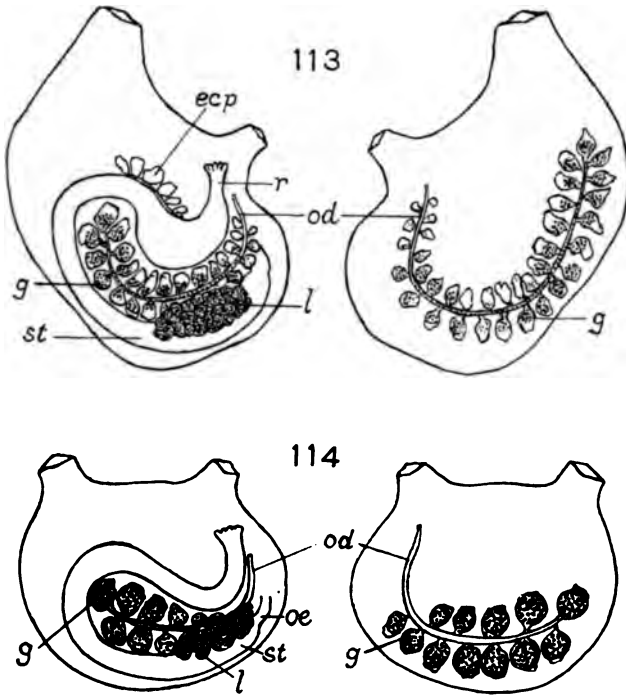
See also note on the *C. vittata* Stimpson reported by Wilson (1900), on p. 440 of this article.

After the study of a considerable amount of material from a wide range of localities, I have come to the conclusion that all the above forms, if not also some others, should be regarded as representing one species, which, though exceedingly variable, does not seem to be divisible upon the basis of any constant and reliable characters.

External form and characters so varied that it is practically impossible to give any description covering them; often the species can be recognized only on dissection. Body more or less oval, but often very irregularly so, sometimes laterally compressed, sometimes not. Attachment variable, occasionally by the whole of the ventral surface, in other examples by a larger or smaller area at or near the posterior end (which

may be produced into a very short extension or peduncle), or by an area on one side. Apertures square, generally rather far apart, raised on papillæ which in some specimens are produced into more or less elongate tubes.

Test, especially in old specimens, tough and opaque, sometimes remarkably so, and often much wrinkled. The wrinkles and folds, though separated by narrow sharply defined furrows, generally have the upper

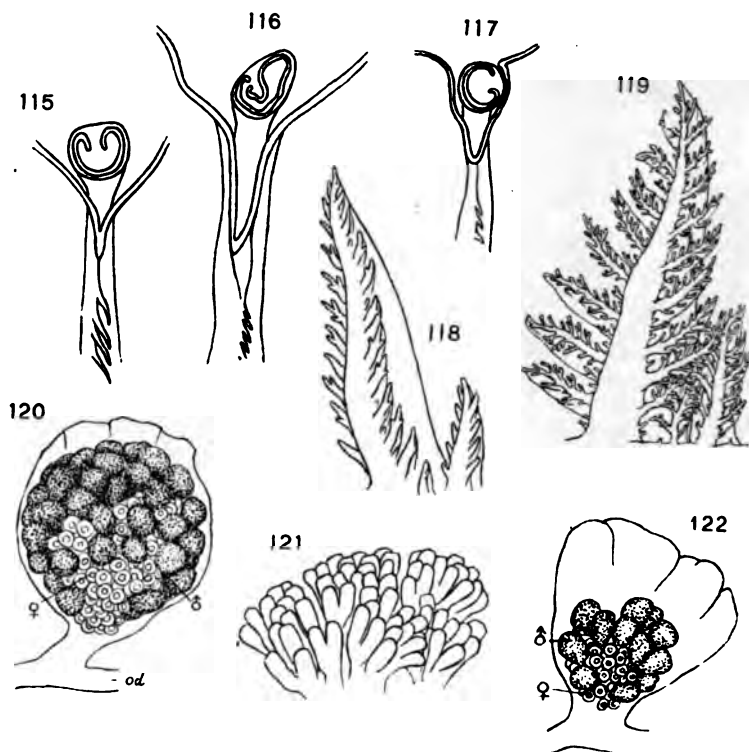


Figs. 113 and 114. *Pyura vittata* (Stimpson), 1852

Fig. 113. Left and right sides of a large individual, slightly enlarged. Fig. 114. Same, small individual from Bermuda (cotype of variety *munifa* Van Name), 1902, $\times 1.6$.

edge rounded. The outer body surface may be incrustated with sand or shell fragments, or overgrown by other organisms, or be nearly clean; around the apertures the surface is usually more or less nodulose. The fresh specimens I have seen are generally reddish or reddish brown, the color becoming more intense (often bright red) near the apertures; the color is often obscured or concealed by the incrusting material. In preservation in alcohol the colors fade to a dirty yellowish or yellowish brown; one small alcoholic specimen from Pensacola, Florida, in the

National Museum collection is a bright brassy yellow externally. The inner surface of the test is more or less pearly. This species reaches a large size; a specimen from Porto Rico measures 49 mm. long and 35 mm. dorso-ventrally; one in the Yale University collection from Fort Macon, North Carolina, collected by Dr. H. C. Yarrow is 65 mm. long and 48 mm. in dorso-ventral diameter.



Figs. 115-122. *Pyura villata* (Stimpson), 1852

Figs. 115-117. Dorsal tubercles showing variation in different individuals, $\times 20$. Fig. 118. Tentacles of an individual from Bermuda, cotype of *P. rubrilabia* (Verrill), 1901, $\times 22$. Fig. 119. Tentacles of a large individual, $\times 12$. Fig. 120. Genital sac fully distended by the reproductive glands, $\times 14$. Fig. 121. Part of liver, $\times 18$. Fig. 122. Genital sac only partly filled by reproductive glands, $\times 14$.

In its internal characters it is also subject to individual variation to an unusual degree.

Mantle with numerous narrow, closely placed muscle bands which extend down on the sides of the body from the bases of the tubes; those from the two tubes cross each other obliquely on the flanks. These are

crossed by more superficial longitudinal muscles not gathered into such definite and conspicuous bands.

Tentacles rather numerous, usually about a dozen large ones and several orders of smaller and less branched ones. They may be arranged with some degree of regularity. Usually the large ones are two or three times compound in a rather regularly pinnate manner; the tips of the small branches were little if at all enlarged in the examples studied. In some individuals the tentacles are less well developed, even the largest being mostly of simply pinnate tapering form.

Dorsal tubercle normally with a U-shaped or C-shaped aperture, the open interval straight or obliquely forward, the horns incurved or more or less spirally rolled, or sometimes one curved inward and the other outward, but in large and old individuals the aperture may have the form of some more complex and often very irregular curve.

Dorsal lamina represented by a series of rather narrow pointed languets.

Branchial sac normally with six folds on each side. The transverse vessels are of four or five orders, the smallest crossing the stigmata. They are slender and numerous. The degree of regularity in the distribution of the several orders varies in different individuals and in different parts of the sac of the same specimen. The internal longitudinal vessels are very slender, and generally not especially numerous in moderate-sized individuals, but there is much individual variation in this respect.

In a fairly large specimen they had this distribution:

Left side

dl 4 (17) 4 (16) 5 (18) 5 (17) 4 (14) 4 (11) 5 en

Right side

dl 5 (17) 5 (17) 4 (18) 5 (19) 5 (16) 5 (11) 5 en

In an extremely large one:

Left side

dl 4 (28) 5 (26) 5 (32) 6 (26) 4 (18) 4 (14) 3 en

Right side

dl 5 (25) 4 (28) 5 (31) 5 (26) 6 (18) 5 (12) 3 en

The stigma are large and regular, the interstigmatic vessels slender. The number of stigmata in the meshes bounded by the transverse and internal longitudinal vessels averages larger in large than in young and small specimens, but aside from this, it appears to vary individually to an unusual degree. On the flat parts of the sac there are only four or five (sometimes only three) in some individuals, while in others there are often six or eight, or even nine, stigmata in a mesh.

Digestive tract in the form of a simple loop the branches of which are more opened out in some specimens than in others. The distal branch of the intestine, near where it passes the stomach, often becomes distended with mud into a saccular enlargement. Rectum usually short, its orifice with a variable number of rounded lobes which are not always well marked. Stomach long and narrow, tapering gradually into the intestine at the pyloric end. Its dorsal and lateral aspects are covered for a considerable distance by the liver, a massive organ consisting of several main lobes, each comprising many rounded lobules built up of numerous short, thick, blunt-ended, radially disposed secreting tubules, some of which divide into two nearly parallel branches (Fig. 121).

There is a large gonad on each side, that of the left side lying within the intestinal loop. Each consists of an elongated oviduct having a curved course and terminating near the base of the atrial tube. Along this (on each side of it and connecting with it by very short lateral branches) small reproductive sacs are located. These sacs vary in number from forty to fifty on each side (there are usually more on the right than on the left) to a dozen or less on each side; when fully developed they contain a central ovary surrounded by numerous small testes. If partially or wholly empty, the sacs resemble endocarps in their character and irregular shape; if fully distended by the development of the eggs and the male glands, they assume a more nearly spherical form, but may bear even then a distal endocarp-like prolongation. In many individuals there is, in addition, on the dorsal side of the intestinal loop, a conspicuous row of endocarps, some of which may develop into genital sacs similar to those of the gonads just described, but usually neither eggs nor male glands can be found in them.

This species is widely distributed. Stimpson's type was from North Carolina (Oak Island Beach, near Smithville); Heller's from Jamaica; Traustedt's from Saint Thomas; Sluiter (1898) reports specimens from Gairaca and Santa Marta, Colombia, and Hartmeyer (1908) from Tortugas, Florida. In the Yale Museum there are large specimens from Fort Macon, North Carolina, collected by Dr. H. C. Yarrow. It is common at Bermuda on stones, corals, etc. At Porto Rico (where it does not appear to be very common, as only four specimens were collected), it was found in shallow water along the shore in Guanica Harbor and at Parguera, and one was dredged in 5 fathoms off Guanica Harbor. The National Museum collection adds Cabañas, Cuba, the Snapper Banks off Pensacola, Florida, in 80 feet depth, and the Bahamas to the list of localities. Stimpson's description is very brief, but there does not appear to be any

other species on the North Carolina coast to which it can possibly apply. The variety *munita* described from Bermuda does not seem to be a valid subspecies; similar specimens occur in West Indian localities. It was based on small individuals covered externally with shell fragments and having but few genital sacs. Verrill's *rubrilabia*, also from Bermuda, was based on individuals with a thick, tough test, with the internal longitudinal vessels close together, and the tentacles poorly developed (mostly simply pinnate), but the differences appear to be within the range of the great individual variation to which this species is subject.

***Pyura antillarum*, new species**

Figures 123-128

Body in the only specimen oblong when seen from one side, somewhat compressed laterally; both apertures on the dorsal surface, the branchial near the anterior end, the atrial near the middle of the body.

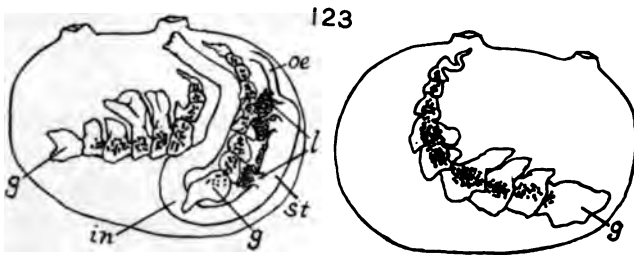
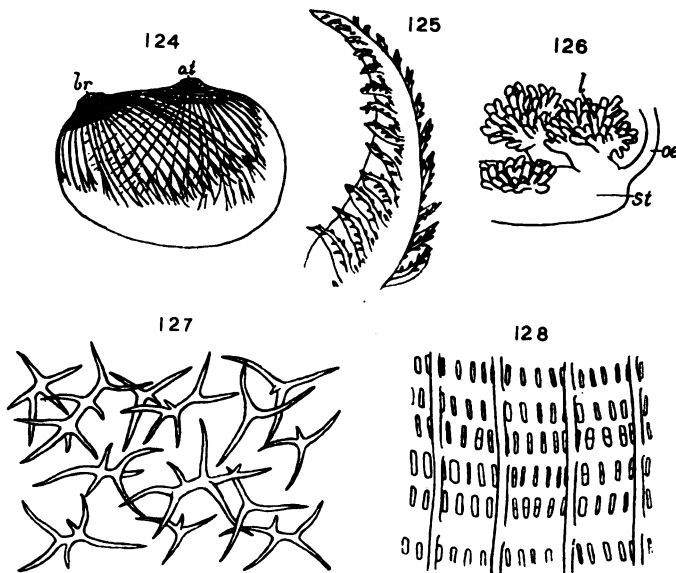


Fig. 123. *Pyura antillarum*, new species
Left and right sides of body, $\times 1.4$.

Both are four-lobed and raised on low elevations; between them a large, irregular ridge of test substance crosses from one side of the body to the other, rising to a much greater height than the papillæ bearing the apertures. Whether this is an individual peculiarity or abnormality, or is more or less characteristic of the species, cannot be determined from the single specimen. Attachment of the body apparently by a small area on the middle of the ventral surface. Length 40 mm., dorso-ventral diameter (exclusive of the above-mentioned transverse ridge) 28 mm. Test yellowish gray, fairly thick, tough and opaque, with many narrow, deep, sharply defined wrinkles on the outer surface; these are mainly longitudinal on the dorsal half of the sides of the body, but elsewhere very irregular. Body surface covered with sand and shells of foraminifera. Internally the test is slightly pearly.

No spicules were found in fragments of the test that were examined, but spicules are present in large numbers in the mantle and vessels of the branchial sac. They are of different form from those of *P. pallida* and other species sometimes separated off as the genus *Rhabdocynthis*, being branched, and having their surface apparently smooth, even under considerable magnification. Spicules having only three or four branches are usually of more or less stellate form, the branches arising from a common central point; in the case of those with more branches there is often a



Figs. 124-128. *Pyura antillarum*, new species

Fig. 124. Body removed from test, showing muscle bands on mantle, slightly enlarged. Fig. 125. Large tentacles, $\times 9$. Fig. 126. Part of stomach and liver, $\times 3.5$. Fig. 127. Spicules from mantle and vessels of branchial sac, $\times 125$. Fig. 128. Small piece of branchial sac from flat part between two folds, $\times 22$.

short central stem or trunk from which branches arise at each end and at intermediate points. The branches are slender and tapering, and suggest in appearance those of a deer's antlers. The largest spicules that were measured were 0.15 to 0.18 mm. in extreme diameter to the tips of the branches.

The mantle is remarkable for its conspicuous network of rather narrow but prominent muscle bands. About fifty of these bands radiate from each of the tubes, extending down on the sides; those from the two tubes cross each other, forming square or diamond-shaped meshes of

considerable size, the bands radiating from the branchial aperture being superficial, and crossing outside those from the atrial aperture. A number of narrow but strong circular bands surround each tube and the area about its base; these are superficial to the radiating bands. The latter fork and break up on the lower part of the flanks into smaller bands which taper rapidly off, and end without extending across or on to the ventral region; there the mantle is thin and practically without muscles.

About ten tentacles of unequal sizes are large enough to be regarded as representing the first two orders. They are long and narrow, gradually tapering, and bear a narrow membrane and a fairly large number of short branches, which are rather sparingly pinnately branched. The tips of the small branches are not swollen. Some smaller and simpler tentacles of various sizes are irregularly distributed in the intervals between these large ones.

Dorsal tubercle scarcely at all developed; the orifice of the duct of the neural gland is merely a minute and inconspicuous cleft. This may, however, be only an individual peculiarity or abnormality of the specimen.

Dorsal lamina represented by a series of rather long narrow languets.

Branchial sac with six rather high folds on the left, and six, or possibly seven, on the right side. The folds diminish fairly regularly in height from the dorsal to the ventral one. Approximate distribution of vessels on the left side:

dl 1 (23) 3 (22) 4 (26) 4 (22) 5 (19) 5 (15) 5 en

From five to seven stigmata generally intervene between adjacent internal longitudinal vessels on the flat parts of the sac. Though in the arrangement of its vessels the branchial sac conforms to the general type found in *P. vittata* and other allied species, it is, as in many other deep-water ascidians, of very delicate structure. The transverse vessels are of three or four orders, additional very slender vessels crossing the stigmata are present only in a few places and for short distances. The transverse and interstigmatic vessels, though wide, are very flat in cross-section; the stigmata are small and narrow in most parts of the sac, and the appearance of the wall of the sac is rather that of a delicate membrane pierced by the stigmata, not of a structure built up of vessels. The internal longitudinal vessels are also of very flattened cross-section, and are not raised on supporting papillæ; one edge is in close contact with the inner surface of the sac.

The digestive tract forms a small, somewhat transversely placed, rather narrow loop, situated in the posterior part of the body. Oesophagus rather long and narrow. Stomach elongate, tapering gradually off into the intestine; it bears on its dorsal and median aspects five rather loose and irregular tufts of branching, blunt-ended hepatic tubules. Rectum moderately long, its aperture with eight bluntly rounded lobes.

On the left side there are two elongate curved gonads partially divided by transverse constructions into eight or ten rather distinct segments that are irregular in outline and prolonged at the edges into sacular extensions of the nature of endocarps. The genital glands occupy the central portions of the segments, but when in a more active functional condition they would no doubt fill them more completely. The glands contain both eggs and testes. The eggs are discharged at the posterior end of the gonad, which is prolonged into a short oviduct or neck curved so as to be directed toward the atrial tube. The ducts from the small oval or pear-shaped testes can be seen upon the free surface of the ovary, where they unite (or at least many of them do) to form a stout common sperm duct which accompanies the oviduct. One of the gonads of the left side lies in the intestinal loop, the other dorsal to it. On the right side there is but one gonad, but it is larger and stouter than those of the left side.

The only specimen was dredged by the Steamer Albatross at Station 2750 near the north end of the chain of the Lesser Antilles (18° 30' N., 63° 31' W., 496 fathoms, fine gray sand). This depth seems to be the greatest thus far recorded for this genus, though, except for the delicate structure of the branchial sac, the species differs little from the shallow water forms.

***Pyura (Rhabdocyathia) momus form pallida* (Heller), 1878**

Figures 129-136

- 1878. *Cynthia pallida* Heller. Sitzungsber. Akad. Wiss. Wien, math.-nat. Kl., LXXVII, p. 96, Pl. III, figs. 17, 18.
- 1881. *Cynthia pallida* Herdman, Proc. Roy. Soc. Edinburgh, XI, p. 60.
- 1882. *Cynthia pallida* Herdman, 'Rep. Voyage Challenger,' Zool., VI, p. 143, Pl. XVII, figs. 17-21.
- 1883. *Cynthia pallida* Traustedt, Vidensk. Meddel. natur. For. Kjöbenhavn, ann. 1882, pp. 119, 133, Pl. v, fig. 12.
- 1885. *Cynthia pallida* variety *billitonensis* Sluiter, Natuurh. Tijdschr. Neder. Ind., XLV, p. 183, Pl. I, fig. 6; Pl. II, figs. 1-11.
- 1885. *Cynthia pallida* Traustedt, Vidensk. Meddel. natur. For. Kjöbenhavn, ann. 1884, p. 35.
- 1886. *Cynthia pallida* (+ *C. pallida* variety *billitonensis*) Herdman, 'Rep. Voy. Challenger,' Zool., XIV, App. A., pp. 405, 406.

1890. *Cynthia pallida* variety *billitonensis* Sluiter, *Natuurh. Tijdschr. Neder. Ind.*, L, p. 331.
1891. *Rhabdocynthia pallida* (part) + *R. pallida* variety *billitonensis* + *R. mauritiana* Herdman, *Journ. Linn. Soc. London, Zool.* XXIII, p. 575.
1898. *Rhabdocynthia pallida* Sluiter, *Mém. Soc. Zool. France*, XI, p. 25.
1904. *Rhabdocynthia pallida* Sluiter, 'Siboga-Exped.,' LVIIa, p. 54.
1905. *Halocynthia pallida typica* + *H. mauritiana* Michaelsen, *Zool. Jahrb.*, suppl., VIII, p. 83.
1905. *Halocynthia pallida* Hartmeyer, *Zool. Jahrb.*, suppl., VIII, p. 384.
1905. *Rhabdocynthia pallida* Sluiter, *Bull. Mus. Hist. Nat. Paris*, 1905, p. 102.
1905. *Rhabdocynthia pallida* Sluiter, *Mém. Soc. Zool. France*, XVIII, p. 14.
1906. *Rhabdocynthia pallida* Herdman, 'Rept. Ceylon Pearl Oyster Fisheries,' V, p. 308, Pl. II, figs. 36-39.
1906. *Halocynthia pallida* Hartmeyer, *Zool. Anzeiger*, XXXI, p. 4, text fig. 2.
1908. *Pyura pallida* (form *typica*) Michaelsen, *Jahrb. Wiss. Anst., Hamburg*, XXV, suppl. 2, pp. 269, 270.
- 1909-1911. *Pyura pallida* (form *typica*) Hartmeyer, Bronn's 'Tier-reich,' III, suppl., pp. 1340, 1629.
1912. [*Pyura*] *pallida* Hartmeyer, *Denk. Akad. Wiss. Wien, math.-nat. Kl.*, LXXXVIII, p. 17.
1912. *Pyura pallida* Hartmeyer, 'Deutsch. Tiefsee-Exp.,' XVI, pp. 361, 363.
1913. *Pyura pallida* Hartmeyer, *Zool. u. anthropol. Ergeb. Forsch., Südafrika*, V, p. 128.
1918. *Pyura pallida* Van Name, *Bull. U. S. Nat. Mus.*, No. 100, I, p. 76, Pl. xxxii, figs. 36-38; text figs. 19-25.
1918. *Pyura momus* form *pallida* Michaelsen, *Jahrb. Wiss. Anst., Hamburg*, XXXV, suppl. 2, p. 10.
1919. *Pyura momus* form *pallida* Michaelsen, *Denk. Akad. Wiss. Wien, math.-nat. Kl.*, XCVII, pt. 10, pp. 34, 53.
1921. *Pyura momus* var. *pallida* Michaelsen, *Arkiv för Zoologi*, XIII, No. 23, p. 1.

Usual form of the body rounded or oblong somewhat compressed laterally, and attached by a small ventrally or more or less laterally situated area. Apertures on the dorsal side, rather widely separated, often raised on papillæ.

Test moderately thick, opaque, rather soft though tough in fresh material, and remaining soft in formalin, but becoming harder in alcoholic specimens. Surface varying from uneven and wrinkled to rather smooth, occasionally overgrown with other organisms. Color of external surface and interior of test usually a dull white (sometimes tinged with pink about the apertures) when not stained or incrustated with mud or other substances. Size sometimes very large; 55 by 45 mm. in longitudinal and dorso-ventral diameter is, however, not usually exceeded in the West Indies.

The species is most readily recognized by the characteristic spicules, present chiefly in the mantle and large blood vessels of the branchial sac.

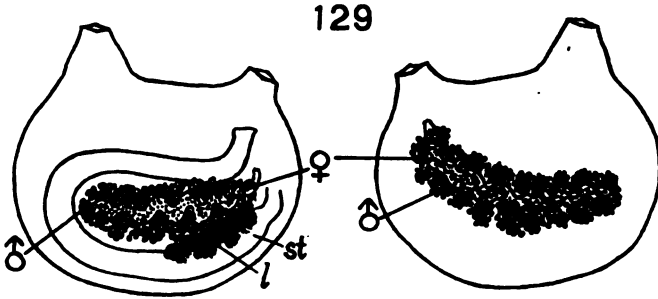


Fig. 129. *Pyura momus form pallida* (Heller), 1878
Left and right sides of body, natural size.

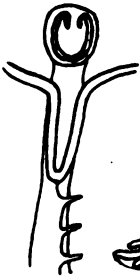
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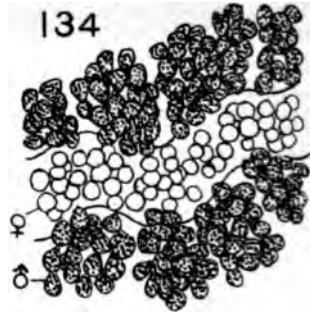
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Figs. 130-135. *Pyura momus form pallida* (Heller), 1878

Fig. 130. Small part of a spicule, $\times 420$. Fig. 131. Spicules. The large group is from the mantle and vessels of the branchial sac, the small group from the test, $\times 35$. Fig. 132. Dorsal tubercle $\times 8$. Fig. 133. Tentacle, $\times 25$. Fig. 134. Part of a gonad, $\times 8$. Fig. 135. Part of liver, $\times 20$.

These are rod-like or needle-like, very variable in size and proportions, but sometimes 2 mm. or more long in large individuals. They taper toward one or both ends and are usually slightly curved. Under magnification, their surface is seen to be covered with minute appressed points or spines arranged in transverse rings. Somewhat similar spicules are found, though less abundantly, in the test, where they are usually very short, stout and straight, and often have one end enlarged into a head, the other being either blunt or pointed. The presence of these spicules has led some writers to make this species the type of a genus or subgenus, *Rhabdocynthia*.

Mantle thin, with rather weak musculature except for some stout bands extending from the bases of the tubes down on the sides. Tentacles irregular in size and arrangement; the larger ones, which are of unequal size and may number from eight to a dozen, are two or three times compound and bear broad membranes. Their branches are not very numerous.

Dorsal tubercle rather small, U-shaped, heart-shaped, or horse-shoe-shaped, with the open interval forward (sometimes obliquely to the left), and both horns usually incurved or inrolled.

Dorsal lamina replaced by a series of languets.

Branchial sac with high, sharply defined folds separated by narrow flat intervals. The number of folds is variable; in West Indian specimens usually eight or nine on a side.

Transverse vessels of four or five orders, often quite regular in their arrangement, the smallest often crossing the stigmata. There are from six to ten stigmata in the large meshes on the flat parts of the sac.

Internal longitudinal vessels only moderately numerous; they were distributed about as follows in a fully adult and fairly large specimen, though in small individuals they will be found considerably less numerous:

Left side

dl 2 (15) 3 (19) 3 (22) 2 (23) 2 (21) 2 (19) 2 (16) 2 (11) 3 en

Right side

dl 4 (16) 3 (20) 2 (22) 2 (23) 2 (22) 3 (18) 2 (14) 2 (10) 1 (5) 0 en

Digestive tract curved in a simple, broad loop. Stomach elongated, bearing a large and dense mass of short hepatic tubules which are crooked and often slightly branched. Rectum short; margin of its aperture not conspicuously lobed in the specimens studied.

One long, horizontally or obliquely placed gonad on each side, each consisting of a central, sinuously curved ovary bordered by numerous small testes. On the left side the gonad lies in the intestinal loop.



Fig. 136. *Pyura momus form pallida* (Heller), 1878
Part of branchial sac, $\times 8$.

Fig. 137. *Microcosmus exasperatus* (Heller), 1878
Part of branchial sac, $\times 6$.

This ascidian is widely distributed in tropical and subtropical seas, ranging from shallow water to a considerable depth. According to Michaelsen, 1918, it is a form or subspecies of *Cynthia momus* Savigny, 1816, from the Red Sea. A number of varieties, subspecies, and allied species of this group have been distinguished, but their characters need not be discussed here, as West Indian specimens are quite typical of the form *pallida* (see Michaelsen, 1908, p. 270; 1919, pp. 30-54.)

It has been recorded by Heller (1878), Traustedt (1883, 1885), and Sluiter (1898) from Jamaica, Curaçao, St. Croix, and St. Thomas; the American and National Museum collections add several localities in Cuba (Paradones near Cienfuegos, Bahia Honda and Cabañas), and Colon, Isthmus of Panama, to the list. The specimens from Paradones were growing in dense clusters with *Phallusia nigra*.

MICROCOSMUS Heller, 1877

Distinguished from *Pyura* chiefly by the possession of a continuous dorsal lamina instead of a row of languets. A further distinction is the narrower intestinal loop, whose branches lie partly in contact with each other.

Microcosmus exasperatus Heller, 1878

Figures 137-144

- 1878. *Microcosmus exasperatus* + *M. variegatus* + *M. distans* (part) Heller, Sitzungsber. Akad. Wiss. Wien, math.-nat. Kl., LXXVII, pp. 99, 100, Pl. III, figs. 19, 20; Pl. v, fig. 27.
- 1883. *Microcosmus variegatus* Traustedt, Vidensk. Meddel. natur. For. Kjöbenhavn, ann. 1882, pp. 122, 134, Pl. v, figs. 10, 11; Pl. vi, fig. 17.
- 1885. *Microcosmus variegatus* Traustedt, Vidensk. Meddel. natur. For. Kjöbenhavn, ann. 1884, p. 42.
- 1891. *Microcosmus exasperatus* + *M. variegatus* + *M. distans* Herdman, Journ. Linn. Soc. London, Zool., XXIII, p. 574, 575.
- 1898. *Microcosmus distans* + *M. exasperatus* + *M. variegatus* Sluiter, Mém. Soc. Zool. France, XI, pp. 6, 26, Pl. II, fig. 35.
- 1900. *Microcosmus miniatus* Verrill, Trans. Conn. Acad. Sci., X, p. 590, fig. 8.
- 1902. *Microcosmus miniatus* Van Name, Trans. Conn. Acad. Sci., XI, p. 396; Pl. LVI, fig. 79; Pl. LVII, figs. 91, 95; Pl. LXII, figs. 129, 130; Pl. LXIV, fig. 148.
- 1908. *Microcosmus exasperatus* (subspecies *typicus*) Michaelsen, Jahrb. Wiss. Anst., Hamburg, XXV, suppl. 2, p. 271, Pl. II, figs. 11-13.
- 1909-1911. *Microcosmus exasperatus* (subspecies *typicus*) Hartmeyer, Bronn's 'Tier-reich,' III, suppl., pp. 1345, 1630, 1633.
- 1913. [*Microcosmus*] *exasperatus* Hartmeyer, Denks. Akad. Wiss. Wien, math.-nat. Kl., LXXXVIII, p. 180.
- 1918. *Microcosmus exasperatus* (subspecies *typica*) Michaelsen, Jahrb. Wiss. Anat., Hamburg, XXXVI, suppl. 2, p. 11.
- 1918. *Microcosmus exasperatus* Van Name, Bull. U. S. Nat. Mus., No. 100, I, p. 81, figs. 30-32, Pl. XXXII, fig. 39.

1919. *Microcosmus exasperatus* Michaelsen, Denk. Akad. Wiss. Wien, math.-nat. Kl., XCV, pt. 10, p. 63, fig. 9.

This widely distributed species has been often described and figured, and a comparatively brief account of it will suffice for its identification. For further details in regard to its structure, variations, and relationships, the reader is referred to Michaelsen, 1908 and 1919.

Body irregularly elongate ovate, generally attached by considerable area on the ventral or posterior ventral side. Apertures on the dorsal side, widely separated, generally on rather low papillæ, which, however, are sometimes produced into tubes of conspicuous length. Size of largest specimen about 55 mm. by 35 mm. by 27 mm. Body surface very rough and uneven with irregular folds, furrows, and ridges, the latter often with rough angular edges. Though often overgrown to some

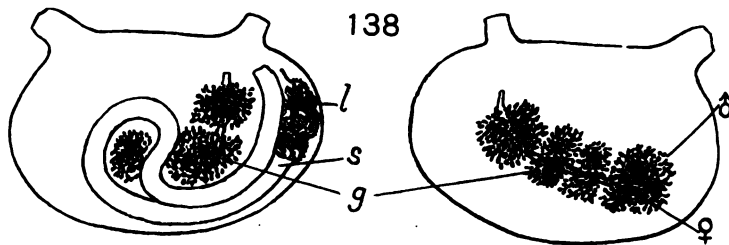


Fig. 138. *Microcosmus exasperatus* Heller, 1878

Left and right sides of body, $\times 1.2$.

extent with algæ, compound ascidians, or other organisms, it is generally not much incrustated by sand or shell fragments. Color of test in life, some shade of red or pink externally and pearly gray or whitish internally. Test fairly thick and tough, often becoming hard and rigid in alcoholic specimens.

Mantle with many very conspicuous muscle bands radiating from the bases of the tubes and extending down onto the sides of the body, where they cross each other nearly at right angles; there are also conspicuous but less regular muscles crossing the ventral region.

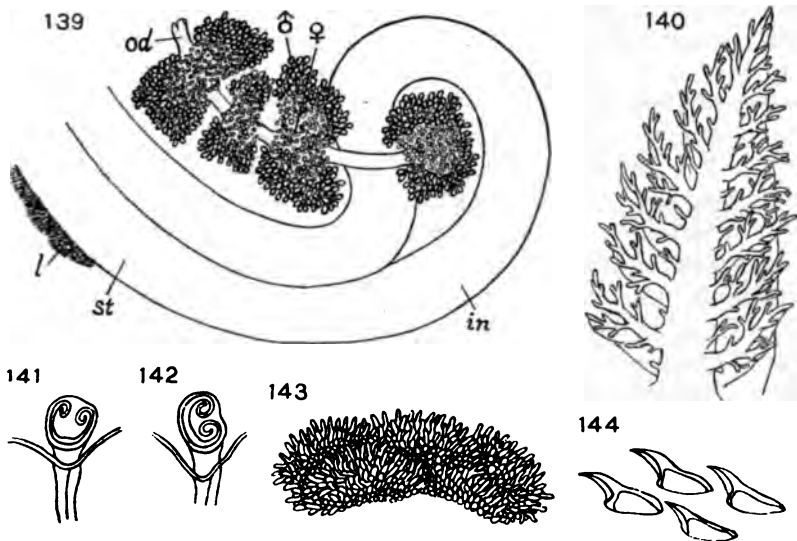
Tentacles of tapering form, the larger ones about eight or ten in number, pinnately branched, and two or three times compound. A variable number of smaller, more or less branched tentacles occupy the intervals between them. Considerable variation was found in the number and length of the primary and secondary branches of the large tentacles in different specimens. In some large specimens from Porto Rico they were found very numerous, and many third-order branches

were present. The tips of the small branches may or may not be slightly enlarged.

Dorsal tubercle generally C-shaped with inrolled horns, the open interval directed forward and more or less obliquely to the left.

Dorsal lamina rather wide, plain-edged.

Branchial sac with about nine (sometimes eight or ten) folds on each side; the folds diminish in height, and in the number of internal longitudinal vessels they bear, fairly regularly from the dorsal to the ventral



Figs. 139-144. *Microcosmus exasperatus* Heller, 1878

Fig. 139. Intestinal loop and gonad of left side, seen from side next to the branchial sac, $\times 6$. Fig. 140. Tentacle, $\times 15$. Figs. 141 and 142. Dorsal tubercles of two individuals, $\times 7$. Fig. 143. Part of liver, $\times 10$. Fig. 144. Minute spines from lining of distal part of branchial tube, $\times 280$.

region, the ninth fold being often much reduced and fading out before the posterior end of the body is reached, or it may be wanting entirely. A small rudiment of a tenth fold is often present on the right side or on both sides, but it extends only a short distance and bears very few vessels. The second fold is often somewhat lower than the third. The folds in this species are ordinarily not very high, and portions of the intervening flat parts of the sac are exposed even when the folds lie flat against the sides. Transverse vessels quite numerous; at least five orders can be recognized in some parts of the sac, those of the first order being very large. The smallest vessels often cross without interrupting the stigmata. The following scheme shows the distribution of the internal longitudinal vessels in a fairly large and typical example:

Left side

dl 4 (25) 4 (22) 5 (24) 4 (20) 3 (19) 4 (16) 3 (12) 3 (9) 2 (6) 1 en

Right side

dl 5 (24) 4 (20) 3 (24) 3 (22) 4 (18) 3 (15) 3 (11) 3 (9) 2 (6) 0 (3) 0 en

Five to eight stigmata ordinarily intervene between internal longitudinal vessels on the flat parts of the sac between the folds.

Intestinal loop narrow, its branches lying close together except at the anterior end, where it opens out into a small loop and is at the same time strongly bent in a dorsal direction. Stomach long and narrow; its wall bears two large hepatic glands near the œsophageal end. The surface of these glands exhibits convolutions which under low magnification suggest those of the human brain. Under high power they are seen to be composed of compacted masses of blindly ending tubules, whose tips project irregularly above the surface.

One gonad on each side of the body. It consists of several masses or segments arranged along a curved oviduct which passes through them in succession. Generally there are three or four segments in the left, and four or five in the right gonad. Each mass or segment consists of a central ovary more or less completely surrounded by the male glands, which are of the usual small pyriform type. When highly developed, the masses may become so large as to obliterate the intervals or clefts between them wholly or in part, so that the gonad may appear continuous or nearly so. The anterior end of the left gonad lies in the open part of the loop formed by the intestine.

This species, which is one of the commonest ascidians of the West Indian region, is widely distributed in tropical and warm-temperate seas, being known from various parts of the West Indies (St. Thomas), Cuba, Porto Rico, Venezuela, Colombia (Santa Marta), Bermuda, East Africa, the Malay region and Formosa, while on the Australian coasts it is represented by a variety (see Traustedt, 1883; Michaelsen, 1908). It grows in shallow water attached to piles, corals, stones, and mangrove roots, as well as in depths to 23 fathoms or more. Many specimens were collected in the vicinity of Guanica Harbor and Parguera, Porto Rico, by the American Museum expeditions; these were mostly found in shallow water along the shore, but several were dredged in depths from 3 to 7 fathoms. Among the numerous specimens in the National Museum collection is one from Sabanilla, Colombia, and one from Station 2617, Steamer Albatross (33° 37' 30" N., 77° 36' 30" W., 14 fathoms), off the South Carolina coast.

***Microcosmus helleri* Herdman, 1881**

Figures 145, 146

1881. *Microcosmus helleri* Herdman, Proc. Royal Soc. Edinburgh, XI, p. 54.
 1882. *Microcosmus helleri* Herdman, 'Rept. Voy. Challenger, Zool.,' VI, p. 121, Pl. xiv, figs. 1-4.
 1885. ?*Microcosmus gleba* + *M. helleri* Traustedt, Vidensk. Meddel. natur. For. Kjöbenhavn, ann. 1884, p. 41, Pl. III, figs. 23-25.
 1891. *Microcosmus helleri* + ?*M. gleba* Herdman, Journ. Linn. Soc. London, Zool., XXIII, p. 574.
 1905. *Microcosmus helleri* Sluiter, Denkschr. med.-nat. Gesell. Jena, VIII, p. 184, Pl. x, figs. 8, 9 (*fide* Hartmeyer).
 1906. ?*Microcosmus manaarensis* + ?*M. longitubis* Herdman, 'Rept. Ceylon Pearl Oyster Fisheries,' V, pp. 311, 312, Pl. II, figs. 23-25.
 1909. *Microcosmus helleri* + ?*M. gleba* Hartmeyer, Bronn's 'Tier-reich,' III, suppl., pp. 1345, 1642, 1644.
 1918. *Microcosmus goanus* + *M. helleri* + ?*M. gleba* Michaelsen, Jahrb. Wiss. Anst., Hamburg, XXXV, suppl. 2, p. 12, text figs. 1, 2.
 1919. *Microcosmus helleri* + ?*M. gleba* Hartmeyer, Kungl. Svensk. Vetensk. Akad. Handl., LX, No. 4, p. 19, Pl. I, figs. 6-9.

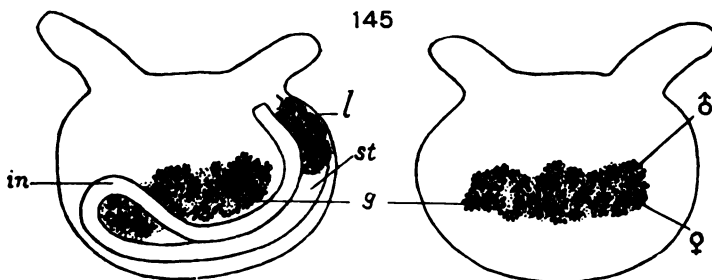


Fig. 145. *Microcosmus helleri* Herdman, 1881
 Left and right sides of body. $\times 1.5$.

Body irregularly spheroidal, longer than broad, and usually not laterally compressed, though sometimes slightly compressed in a dorso-ventral direction. Tubes arising from the dorsal surface at a varying distance apart; they are long, narrow, and diverging in most specimens, and often very crooked. In some specimens, however, they are quite short, perhaps because of contraction. Size of the largest specimen, 45 mm. long, 32 mm. in dorso-ventral and 29 mm. in lateral diameter, exclusive of the tubes. These arise more than 10 mm. apart; the branchial tube is about 16 mm. long, the atrial about 11 mm. long.

Body surface rough and raised into small, sharp, irregular ridges and small irregular processes. It is so completely incrustated with sand grains, shell and coral fragments, etc. (which are imbedded in the test of the body and in the substance of the processes, as well as firmly at-

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Fig. 146. *Microcosmus helleri*
Herdman, 1881

Part of branchial sac, $\times 10$.

tached to their surfaces) and so plastered with loosely adherent mud that the surface is generally entirely concealed and the animal often looks like a ball of mud and débris. Most of the specimens had evidently lived buried in the mud, the long tubes (probably capable of greater extension during life) enabling them to breathe and feed when so situated. (One specimen, from off Guanica Playa, was attached to an oyster shell, and evidently grew in a more exposed position; some algae were growing upon its surface, which is otherwise only lightly incrustated with foreign matter; its tubes are little more than papillæ, and arise very near together.) The test is tough but only moderately thick; its lining is slightly nacreous. The test extends into and forms a thin lining to the branchial tube; the terminal or posterior margin of this lining is produced into four large, rigid, somewhat spoon-shaped or obtusely pointed lobes that project in a convergent manner into the lumen of the branchial tube anterior to the circle of tentacles. In spite of the most careful search I was unable to demonstrate any small spines in the lining of either the branchial or atrial tube, such as are present in *M. exasperatus*.

Mantle rather thin, but with strong, rather closely spaced muscle bands on many parts of its surface, the most conspicuous of them, as in other species of this genus, being long narrow bands composed of several fibers side by side, which extend down on the flanks from the tubes, those from

one tube crossing those from the other so as to form small square or obliquely four-sided meshes.

Tentacles of rather regular pinnate form, the largest ones larger and more extensively branched than in most individuals of *M. exasperatus*, being three times (on some of the branches four times) compound. The minute branches end in blunt, somewhat swollen tips. The larger tentacles are not all of uniform size and number only eight or less; smaller and less complex tentacles are present in the intervals, but are not very numerous. In some individuals several tentacles (two to four or more) are very much larger than the rest, but these are not necessarily symmetrically placed in the circle.

Dorsal tubercle C-shaped, the open interval directed forward and the horns spirally rolled inward. Neither the dorsal tubercle nor the tentacles appear to differ sufficiently from those of *M. exasperatus* to require illustration.

Dorsal lamina a plain membrane, rather narrow.

Branchial sac very regular in structure, with six well-developed folds on each side of the body. Additional rudimentary folds were not observed in any of the specimens studied (five individuals). The folds are for the most part so high as to cover the intervening flat part of the sac and a part of the fold above when in their normal position. Transverse vessels of at least five orders can be recognized, the smallest crossing without interrupting the stigmata. They are usually quite regularly arranged (except that the fifth-order vessels are wanting in many places), according to the usual scheme:

1 5 4 5 3 5 4 5 2 5 4 5 3 5 4 5 1.

Internal longitudinal vessels narrow, numerous, and rather near together on the folds, but considerably more widely and unevenly spaced on the intervening flat parts of the sac. It is often hard to decide whether certain of the vessels should be counted as belonging to the flat portion or to the basal part of one of the adjacent folds. Approximate distribution of the internal longitudinal vessels in a moderately large individual:

Left side

dl 3 (24) 2 (19) 2 (25) 4 (22) 3 (16) 3 (13) 1 en

Right side

dl 4 (23) 3 (18) 2 (26) 4 (23) 3 (17) 3 (14) 0 en

Several others examined showed about the same distribution. Stigmata very narrow and very regular in their arrangement. The meshes formed by the transverse and internal longitudinal vessels are quite variable

in size on the flat portions of the sac on account of irregular spacing of the latter vessels, but there are commonly at least nine or ten and sometimes twelve or fifteen stigmata in a mesh.

Stomach long and narrow, tapering off into the intestine. A part of its wall near the œsophageal end bears a hepatic gland. Intestinal loop long and narrow, its branches lying close together except for a short distance at the anterior end (the closed end), where they are spread apart to form a small open space in which part of the gonad lies. The anterior part of the intestinal loop is much less sharply bent up dorsally than in *M. exasperatus*. As the intestine is visible through the mantle, this character is of convenience in distinguishing the two species.

One gonad of elongate outline is present on each side of the body. Each consists of a layer of small pyriform male glands attached to the inner surface of the mantle. These in turn are covered by the ovarian portion of the gonad, which lies in contact with the branchial sac. On the left side the anterior end of the gonad lies chiefly within the above-mentioned loop formed by the intestine. A tendency to division of the gonads into two or three segments by narrower necks is noticeable in many cases, but this was rarely carried to such an extent as to break the continuity of the mass in any of the specimens studied.

The specimens of this species were all dredged off the coast of Porto Rico in the vicinity of Guanica and Tallaboa by the American Museum expeditions. Their localities are as follows:

East of Caribe Islands, $5\frac{1}{2}$ to $8\frac{3}{4}$ fathoms, 27 specimens; off Guanica Playa, 18 feet, sand and algæ, 1 specimen; between Ratones and Caribe Islands, 6 to 11 fathoms, 1 specimen.

This is a species very widely distributed in the warm parts of the world. Herdman's type was from Torres Strait, Sluiter reports it from Amboina, and Michaelsen (1918) redescribed it under the name *goanus* from Delagoa Bay, Portuguese East Africa, though doubtful of its distinctness from Herdman's species. The identity of the two seems to have been satisfactorily established by Hartmeyer (1919). I am inclined to go farther than that author and regard *M. gleba* Traustedt, 1885, from Banka, as another synonym, and *M. manaarensis* and *M. longitubis* Herdman, 1906, from Ceylon, as only very doubtfully distinct.

[NOTE. An additional, apparently entirely distinct species of this genus (*M. anchylodeirus*) is described by Traustedt (1883, p. 121. Pl. VI, fig. 18) from St. Thomas, W. I. It has seven folds on each side and a branchial sac with very irregular vessels. See also p. 485.]

Molgulidæ Lacaze-Duthiers, 1877[= *Cæsiridæ* auct. mult.]

Simple ascidians, usually having the tentacles compound and the branchial sac with longitudinal folds, more or less spirally arranged stigmata, and a kidney (in the form of a single completely closed sac in which concretions form) situated on the right side of the body. Dorsal lamina continuous but often toothed.

MOLGULA Forbes and Hanley, 1848[= *Cæsira* auct. mult.]

The largest genus of the family. The branchial sac is provided with folds (usually six or seven on each side), each bearing a number of internal longitudinal vessels and usually a row of infundibula with spiral stigmata along its summit; the spirals are more or less imperfect and interrupted. A gonad is usually present on each side of the body.

Molgula occidentalis Traustedt, 1883

Figures 147-152

1860. *Molgula* species, Stimpson. Amer. Journ. Sci., (2) XXIX, p. 443.
 1883. *Molgula occidentalis* Traustedt, Vidensk. Meddel. natur. For. Kjöbenhavn, ann. 1882, pp. 113, 128, Pl. v, figs. 4, 5; Pl. vi, fig. 14.
 1891. *Molgula occidentalis* Herdman, Journ. Linn. Soc. London, Zool., XXIII, p. 567.
 1909-1911. *Cæsira occidentalis* Hartmeyer, Bronn's 'Tier-reich,' III, suppl., pp. 1323, 1624, 1629.
 1914. *Molgula occidentalis* Hartmeyer, Sitzungsber. Gesell. naturf. Freunde, Berlin, p. 7.

Body of rounded or oval outline; the depth may or may not exceed the length. It is not much compressed laterally. Apertures on the dorsal side, usually situated not far apart, sometimes sunk in the depressions between rounded prominences of the test that are present on that part of the body, in other cases raised on low papillæ. Size of largest specimen examined, 44 mm. long, 45 mm. in dorso-ventral diameter, and nearly 25 mm. wide from side to side when distended.

Test rather thin, though tough, on most parts of the body; on the dorsal region it becomes quite abruptly very thick and hard. The surface is sometimes roughened by rather fine wrinkles and much incrustated with mud, sand, shell fragments, etc., these materials being in part imbedded in the test and in part adherent to short fibrous processes with which parts of the surface are provided, but some specimens have much of the body bare of foreign matter and fairly smooth. The color is usually that of the incrusting sand or mud; where the surface is exposed it is of a dingy yellowish or gray color. Mantle thin and semitransparent, some-

times dark colored. There are a few stout muscle bands radiating from the tubes and extending part way down the sides, and, as shown in Traustedt's figures, there are rows of short transverse bands on many parts of the sides and ventral region, and well-developed circular muscles about the apertures.

About a dozen large tentacles are present in the largest specimens beside some additional smaller tentacles. These structures are difficult to count because of their crowded condition, and it is often difficult to distinguish some of the closely placed smaller tentacles from the basal

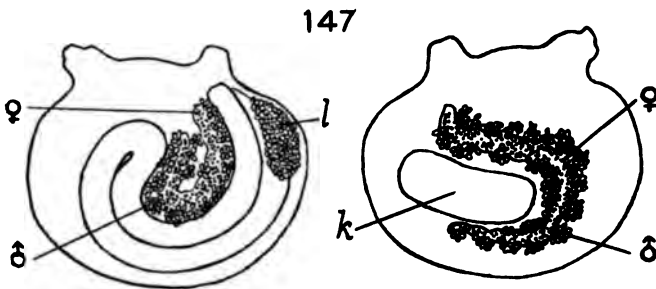


Fig. 147. *Molgula occidentalis* Traustedt, 1883
Left and right sides of body, $\times 1.5$.

branches of the larger ones. The large tentacles are three times pinnate, the small branches ending in slightly enlarged rounded tips.

Dorsal tubercle C-shaped; open interval more or less directly to the left in all of a number of specimens in which this character was examined; horns inrolled.

Dorsal lamina plain-edged.

Branchial sac with six well-developed folds on each side; they are broad and sharply defined, and bear many internal longitudinal vessels. Traustedt's description, probably based on a single specimen, gives seven folds on each side, the first fold being incomplete. I have found a more or less well-developed plication between the dorsal lamina and the first true fold in many individuals (including examples from different localities) on one or both sides of the body, and this is probably what Traustedt counted as the first fold. It bears a few somewhat irregular internal longitudinal vessels, but I cannot consider it homologous with the remaining six. In many examples it is so slight as to be readily overlooked; in many it is wanting completely on one or both sides. This extra fold seems to be of the same nature as that present in *Polycarpa oblecta*, and *P. spongiabilis* (see p. 422) and is very probably due to a mechanical cause, as suggested in the description of *P. oblecta*.

Distribution of the internal longitudinal vessels in a medium sized individual:

Left side

dl [5] 1 (11) 0 (12) 0 (11) 0 (10) 1 (9) 1 (7) 0 en

Right side

dl [6] 0 (12) 0 (12) 1 (10) 1 (10) 0 (8) 0 (6) 0 en

In a larger example, 39 mm. long, which was without any trace of the extra fold, they were distributed as follows:

Left side

dl 8 (15) 1 (17) 1 (16) 2 (14) 1 (11) 1 (9) 0 en

Right side

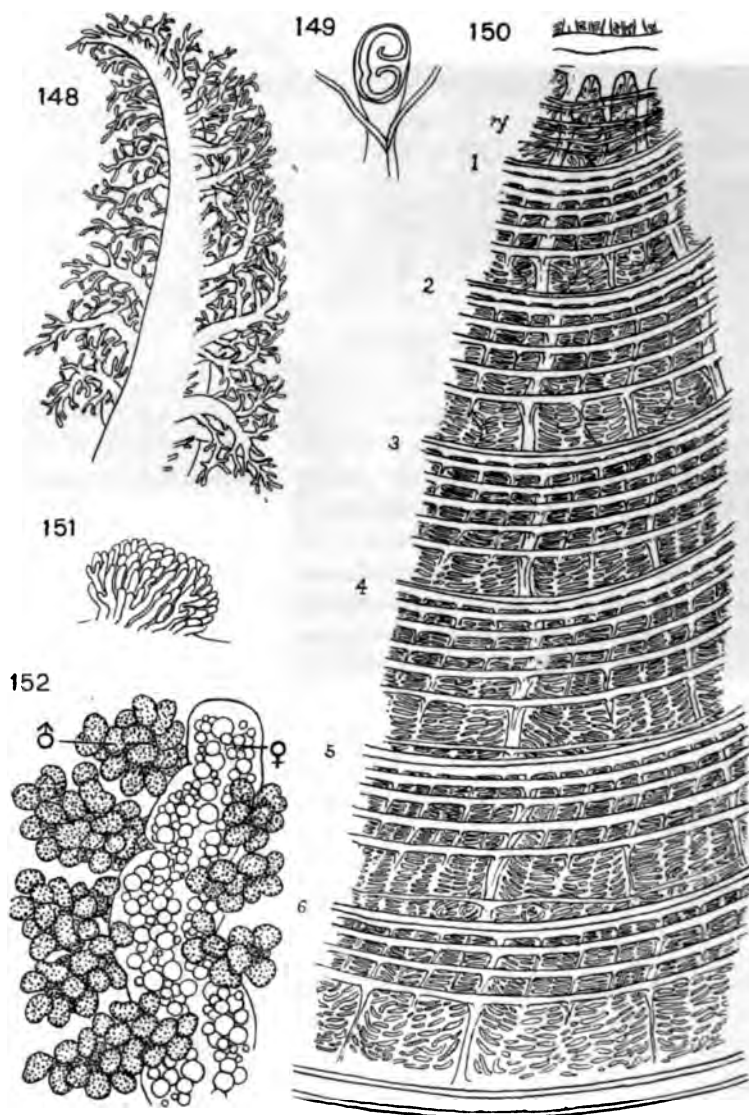
dl 7 (17) 1 (16) 1 (14) 2 (12) 2 (10) 1 (7) 1 en

Four (in the ventral parts of the sac often five) orders of transverse vessels are recognizable on the folds, where they are quite regularly arranged. On the flat spaces between folds the smaller ones become irregular and often disappear. Stigmata very numerous, mostly straight or but little curved; never very long and narrow. They are mainly longitudinal and arranged in transverse columns separated by the transverse vessels of the smaller orders. The small interstigmatic vessels branch and curve a good deal, and this, as well as the irregularity of the smaller transverse vessels, disturbs or obscures their arrangement in columns in many places, but in others their regularity is quite striking. No definitely formed infundibula with spirally arranged stigmata were demonstrated even on the folds, whose knife-like sharpness would hardly allow of their presence. On the flat intervals between folds, especially in the ventral region of the sac, a tendency to a spiral arrangement of the stigmata is present in a few places. A considerable number of irregularly branching vessels ramify on the inner surface of the sac.

Intestinal loop very narrow (its branches in contact for practically the whole length). It is bent into about three quarters of a circle. Stomach with a large, greenish hepatic gland consisting of an immense number of very minute, short, sparingly branched tubules.

Kidney large and broad, elongate-oblong in shape; usually not much curved.

A large gonad is present on each side of the body. Each gonad consists of an elongate curved tubular ovary bordered along its sides with clusters of small oval or pear-shaped male glands. Right gonad very long and narrow, and bent around the kidney so as to surround all except the posterior part of it. The dorsal end of the ovary, where the aperture



Figs. 148-152. *Molgula occidentalis* Traustedt, 1883

Fig. 148. Large tentacle, $\times 9$. Fig. 149. Dorsal tubercle, $\times 12$. Fig. 150. Part of branchial sac, $\times 12$. Fig. 151. Part of liver, $\times 6$. Fig. 152. Closed end of left gonad, $\times 15$.

for the discharge of the eggs is situated, is bent dorsally toward the base of the atrial tube. Left gonad situated in the curve formed by the dorsal side of the digestive tract. The ovary is bent into a U-shaped loop, with the open end dorsal; the small groups of male glands lie, in the specimens studied, chiefly along the outside of the curve (hence between the ovary and intestine), but some are in the bend of the loop formed by the ovary. When well developed the left ovary and testes form a compact group, broad below and narrow above (that is, in the dorsal part), the bend of the loop being completely filled.

The form of the gonads just described seems to be characteristic of this species and furnishes the best means of recognizing it, as the gonads are usually easily seen through the mantle as soon as the animal is removed from the test.

This species ranges from North Carolina (Fort Macon, near Beaufort, and the mouth of the Cape Fear River) to the West Indies (Porto Rico, off Guanica Playa, 18 fathoms; Guanica and San Juan Harbors), but appears to be especially common on the Florida coasts, where it is the principal representative of the family. It ranges in depth from low-water mark, often growing on mangrove roots, to 21 fathoms (off the west coast of Florida). Traustedt's type was from the West Indies (probably from the former Danish possessions).

***Molgula manhattensis* (De Kay), 1843**

Figures 153 and 154

- 1843. *Ascidea manhattensis* De Kay, 'Zoology of New York,' V, 'Mollusca,' p. 259.
- ?1852. *Molgula sordida* Stimpson, Proc. Boston Soc. Nat. Hist., IV, p. 229.
- 1873. *Molgula manhattensis* Verrill and Smith, 'Rep. on Invert. Animals of Vineyard Sound,' pp. 699, 311, 445, etc., Pl. xxxiii, fig. 250.
- 1898. *Molgula manhattensis* Metcalf, Anat. Anzeiger, XVI, p. 469.
- 1900. *Molgula manhattensis* Wilson, Amer. Naturalist, XXXIV, p. 354.
- 1905. *Molgula manhattensis* Mayer, 'Seashore Life,' p. 170, fig. 119.
- 1912. *Cæsira manhattensis* Van Name, Proc. Boston Soc. Nat. Hist., XXXIV, p. 471, Pl. xlv, figs. 11-13, Pl. lxxi, figs. 151, 152, text figs. 4, 5.
- 1912. *Cæsira papillosa* Huntsman, Trans. Canadian Inst. (1911), pp. 112, 139. (Not *Molgula papillosa* Verrill, 1871.)
- 1913. *Molgula manhattensis* Sumner, Osburn and Cole, Bull. U. S. Bureau of Fisheries, XXXI, pp. 155, 157-160, 729; 730; chart 191.
- 1913. *Molgula manhattensis* Miner, Amer. Museum Journal, XIII, p. 91, text fig.
- 1914. *Molgula manhattensis* Hartmeyer, Sitzungsber. Gesell. naturf. Freunde, Berlin, p. 7.
- 1915. *Molgula manhattensis* Hartmeyer, Mittheil. Zool. Mus. Berlin, VII, p. 313.
- 1916. *Molgula manhattensis* Pratt, 'Manual Common Invert. Animals,' p. 665, text fig. 1007.

Additional references and synonyms and a more detailed description are given in Van Name, 1912 (see above).

Body usually nearly globular when distended, except for some degree of lateral compression. The tubes are diverging and often curved. They arise on the dorsal region either a little way apart or quite close together. The test is firm, tough, and moderately thick, with an irregularly roughened surface, and provided in places with short, irregular hair-like processes, which would not be conspicuous were it not for the sand grains, shell fragments, bits of eel grass and other débris which adhere to them. The maximum diameter usually does not exceed 20 to 25 mm. The general color, when fresh, is a dingy yellowish or greenish gray, or olive.

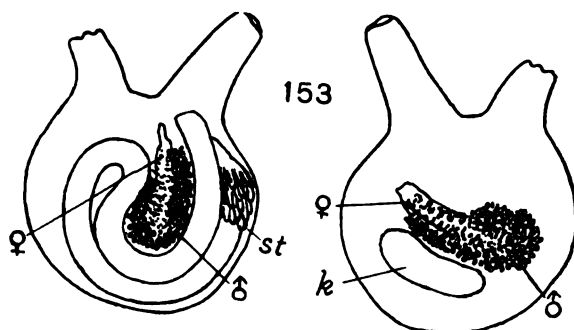


Fig. 153. *Molgula manhattensis* (De Kay), 1843
Left and right sides of body, $\times 1.8$.

On removal from the test, this animal is readily distinguishable from *M. occidentalis* by the branchial sac and gonads. There are six branchial folds on each side. These are low and bear a maximum of six or seven internal longitudinal vessels. The stigmata are usually quite long and narrow, and irregularly curved, and form well-defined spirals on the folds and here and there also on the flat parts of the sac, especially in the ventral regions. On the left side, the ovary is flask-shaped and the intestinal loop is bent in a more circular shape than in *M. occidentalis*; on the right side, the gonad is shorter than in that species, and its ovary is practically straight. It is situated dorsal to the kidney, and does not bend around it. The kidney is smaller and shorter than *M. occidentalis*, and is bean-shaped. The dorsal tubercle is similar to that of the latter species, but usually has the open interval to the rear.

This species ranges from St. Andrews, New Brunswick (Huntsman, 1912), to Louisiana (Shell Island, Mussel Bayou, Drum Bay, etc.). It

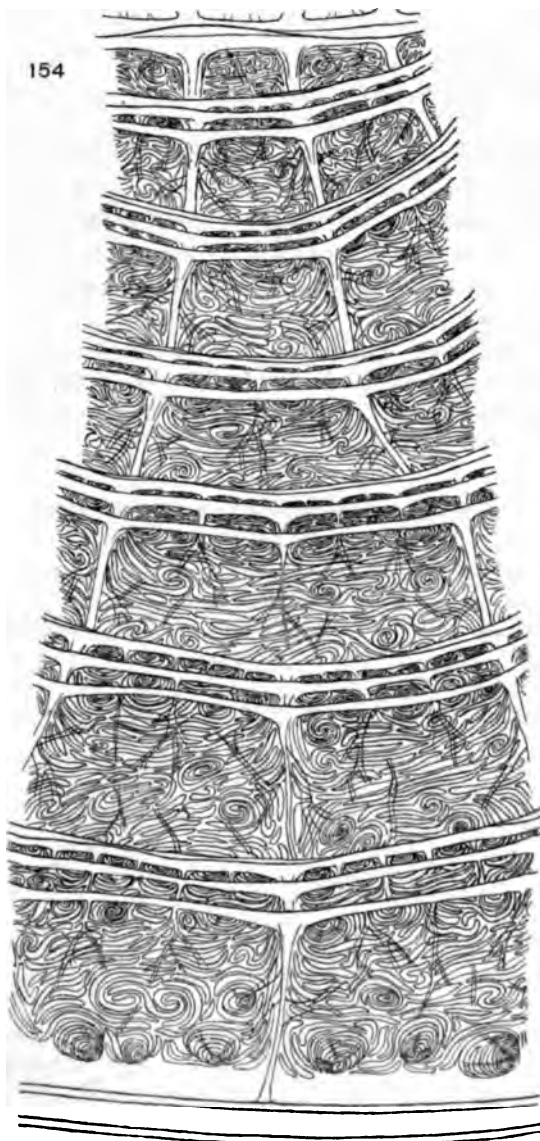


Fig. 154. *Molgula manhattensis* (De Kay), 1843
Part of branchial sac, $\times 15$ (from Proc. Boston Soc. Nat. Hist., XXXIV).

is a shallow-water form, often growing abundantly on eel grass, piles, stakes, etc., but is recorded to depths of 16 fathoms on the New England coast and 27 fathoms in Chesapeake Bay. From Cape Cod to North Carolina it is the commonest of the larger simple ascidians. The dredgings of the Steamer Fish Hawk in 1915 indicate that in most of the deeper parts of Chesapeake Bay it is not only the commonest but practically the only species of ascidian. I have no records from Florida, and failed to find it in my collecting on the southern part of the coast of that State, though there are several stations for it from the South Carolina coast. Its distribution may, therefore, be discontinuous and interrupted by the Florida peninsula.

The National Museum collection contains several small specimens from the back of a large blue crab (*Callinectes*) supposed to have been caught in Chesapeake Bay. It is apparently rare to find ascidians on a crab of such active habits.

***Molgula lutulenta* (Van Name), 1912**

Figure 155

1912. *Cæsira lutulenta* Van Name, Proc. Boston Soc. Nat. Hist., XXXIV, p. 468, Pl. xlv, figs. 7-10; Pl. LXXIII, fig. 168; text figs. 2, 3.
 1914. *Molgula lutulenta* Hartmeyer, Sitzungsber. Gesell. naturf. Freunde, Berlin, p. 7.

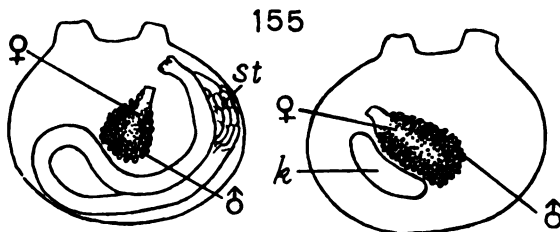


Fig. 155. *Molgula lutulenta* (Van Name), 1912

Left and right sides of body, $\times 3$.

This species does not require more than a brief mention here, as it is only known from rather deep water (67 to 142½ fathoms) far off the coast of southern New England and the Middle States, in the vicinity of 40° N. and 70° and 71° W.

It is a small species of elliptical outline, not exceeding about 15 mm. in greatest diameter, though it is densely covered externally with long moss-like fibrous processes to which sand and mud adhere, making it appear larger. Internally, it differs from *M. manhattensis* in the large

infundibula, on which the stigmata form very regular spirals, the much less bent intestinal loop, and in the gonads of both right and left sides being short, broad, and flask-shaped. There are as in that species, six branchial folds on each side.

[NOTE. *Molgula eugyroides* Traustedt (1883, p. 112, Pl. v, figs. 1-3) from Bahia, Brazil, and *M. contorta* Sluiter (1898, p. 28, Pl. II, figs. 39, 40) from Colombia, are species entirely distinct from any of the above. See p. 486.]

BOSTRICHOBRANCHUS Traustedt, 1883

In this genus the folds of the branchial sac have disappeared and are indicated only by seven broad, flat, internal longitudinal vessels on each side. Stigmata on internally projecting and often very high conical infundibula, on each of which they form a perfect double spiral interrupted only at the summit. Infundibula very numerous and irregularly distributed in adult individuals. A gonad is normally present on the left side only.

Bostrichobranchnus pilularis Verrill, 1871

Figures 156-159

- 1871. *Molgula pilularis* Verrill, Amer. Journ. Sci., (3) I, p. 58, fig. 4c.
- 1872. *Eugyra pilularis* + *Molgula pellucida* Verrill, Amer. Journ. Sci., (3) III, pp. 211, 289, Pl. VIII, figs. 2, 3.
- 1873. *Eugyra pilularis* + *Molgula pellucida* Verrill and Smith, 'Rept. on Invert., Animals of Vineyard Sound,' pp. 509, 699, 700, etc., Pl. XXXIII, fig. 249.
- 1878. *Molgula pellucida* Coues and Yarrow, Proc. Acad. Nat. Sci. Philadelphia, 1878, p. 303.
- 1883. *Bostrichobranchnus manhattensis* Traustedt, Vidensk. Meddel. natur. For. Kjöbenhavn, pp. 109, 128.
- 1885. *Bostrichobranchnus manhattensis* Traustedt, Vidensk. Meddel. natur. For. Kjöbenhavn, ann. 1884, p. 22, Pl. I, figs. 10-12.
- 1912. *Bostrichobranchnus pilularis* Van Name, Proc. Boston Soc. Nat. Hist., XXXIV, p. 458, Pl. XLIII, figs. 1-4; Pl. XLIV, figs. 5, 6; Pl. LXIX, fig. 137; text fig. 1.
- 1913. *Eugyra pilularis* + *Bostrichobranchnus molguloides* + *Molgula pellucida* + *Eugyra glutinans* Sumner, Osburn and Cole, Bull. U. S. Bureau of Fisheries, XXXI, pp. 75, 157, 186, 729; Chart 190.
- 1916. *Eugyra pilularis* + *Bostrichobranchnus molguloides* + *Molgula pellucida* Pratt, 'Manual Common Invert. Animals,' p. 665.

Not *Molgula pellucida* MacDonald, 1859, from Australia.

This species has occasionally been confused with *Molgula manhattensis* (De Kay), 1843, described above. Additional synonyms and a detailed description, with special reference to the remarkable arrangement of the branchial stigmata, have been given in a previous paper (Van Name, 1912), so that only the more important characters will be mentioned here.

As usually found, this animal resembles a small ball of mud or sand; the body is globular or ellipsoidal, and is more or less covered externally with short, minute fibers to which fine sand and mud adhere. This foreign material is, however, rather easily rubbed off, and sometimes specimens are found in which the surface is nearly smooth and bare. Tubes elongate, equalling or exceeding the body diameter in length when extended, tapering, straight or slightly curved, and arising near together from the dorsal side of the body. These tubes, as well as a small definitely circumscribed area on the surface of the body, within which they both have their bases, are free from adhering sand or mud. They can usually be entirely retracted, and are ordinarily found so in preserved material, but in some specimens the test about their bases is thick

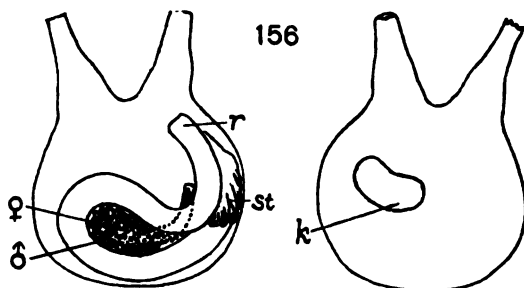


Fig. 156. *Bostrichobranthus pilularis* (Verrill), 1871
Left and right sides of body, tubes extended, $\times 1.3$.

and tough, and it is doubtful whether they can be drawn in to any great extent. (*Molgula pellucida* Verrill, 1872, appears to be based on specimens having little adhering mud or sand, and such non-retractile siphons. With the information at present available it does not appear to be valid, even as a true variety.)

Branchial aperture six lobed; atrial aperture square.

Test over most of the body thin and, when the foreign matter is rubbed off, transparent and colorless, or with a bluish or greenish tint. The body is usually unattached, the animal living buried in the sand or mud. It sometimes reaches a considerable size (25 to 35 mm. in maximum diameter), but is commonly much smaller, often only 8 to 10 mm., even when adult.

Excepting the tubes, which have conspicuous circular and longitudinal muscle bands, the mantle is thin and in most parts without muscles. The longitudinal bands of the tubes extend out on to the body but a very short distance, ending abruptly only a little way from the

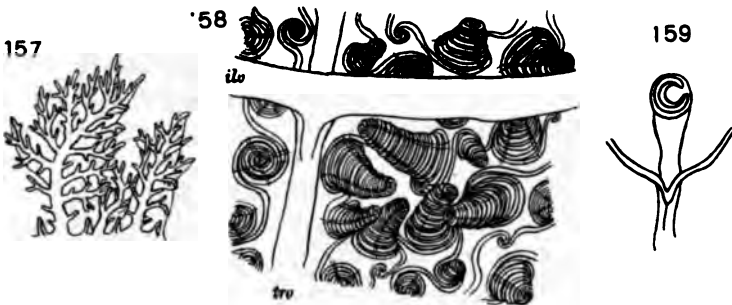
base of the tubes; along each side of the mid-ventral line there is a row of many very short but stout bands transverse to that line and parallel to each other. None of these reach to or extend across the mid-ventral line.

Tentacles rather numerous, of four orders; the largest two or, to some extent, three times compound.

Dorsal tubercle C-shaped; open interval to the left.

Dorsal lamina plain-edged.

Branchial sac entirely without folds. There are seven very wide but thin and flat internal longitudinal vessels, and five transverse vessels on each side. The walls of the sac are occupied by internally projecting infundibula, very tall and numerous, and distributed without apparent



Figs. 157-159. *Bostrichobranchus pilularis* (Verrill), 1871

Fig. 157. Tentacles, $\times 24$. Fig. 158. Small piece of branchial sac (inner aspect), $\times 32$. Fig. 159. Dorsal tubercle, $\times 18$.

regularity in old individuals. On each infundibulum a stigma winds uninterruptedly from the base to the summit, where it ends; another begins there and winding to the base between the coils of the first it crosses the flat part of the sac to an adjacent infundibulum on which it winds to the summit, so that the stigmata form chains of connected spirals occupying several or many adjacent infundibula.

Alimentary tract forming a rather narrow, moderately bent loop. Stomach elongate; a part of its wall is differentiated into a hepatic organ.

One gonad, consisting of a flask-shaped or elongate ovary bordered by numerous small testes which are oval or two- or three-lobed. It lies in, more or less overlapped or covered by, the intestinal loop; the ovary is prolonged into a short, stout tube or oviduct, extending posteriorly and dorsally. No gonad on the right side (see exception noted below).

Kidney situated on the right side, posterior to the middle of the body.

This genus is represented along the Atlantic coast of North America from the Gulf of St. Lawrence, if not from farther north, to the west coast of Florida. It occurs in depths of from $\frac{1}{2}$ to 120 fathoms (the latter depth in $39^{\circ} 57' N.$, $70^{\circ} 56' W.$). This wide distribution and the variability exhibited by the specimens would suggest that there is more than one species, but I can find no sufficient basis for such a conclusion. It is much commoner than is generally known, as it lives buried in the sand or mud and is therefore usually only to be obtained by digging or dredging. Thus far, the only record from the Southern States has been from Fort Macon, North Carolina (collected by Coues and Yarrow), but the National Museum contains two small specimens from the Gulf coast of Florida, from the banks near $28^{\circ} 56' N.$ and $83^{\circ} W.$, and from St. George's Sound, respectively. The St. George's Sound specimen is unique in having a gonad on each side of the body. Though I have dissected many examples of this species from various localities, I have never found more than one gonad except in this case and therefore regard it as merely an individual abnormality, perhaps a sporadic case of reversion, as this genus is doubtless derived from ancestors having a gonad on each side.

If sought for by the proper methods, this species will probably be found to be much more numerous and widely distributed along our southeastern coast than has been supposed, but it is not unlikely that its distribution is discontinuous and interrupted by the southern part of the Florida peninsula, as appears to be the case with *Molgula manhattensis*.

LOCAL LISTS OF SPECIES

A.—Ascidians from Porto Rico (26 species and forms).

- Polyclinum constellatum* Savigny, 1816
- Aplidium lobatum* Savigny, 1816
- Trididemnum savignii* (Herdman), 1886
- Trididemnum savignii* form *poriles* (Van Name), 1902
- Trididemnum solidum* (Van Name), 1902
- Leptoclinum macdonaldi* (Herdman), 1886
- Didemnum candidum* Savigny, 1816
- Polycitor* (*Eudistoma*) *olivaceus* (Van Name), 1902
- Clavelina oblonga* Herdman, 1880
- Holozoa bermudensis* (Van Name), 1902
- Perophora viridis* Verrill, 1871
- Phallusia nigra* Savigny, 1816
- Phallusia hygomiana* Traustedt, 1882

Phallusia sydneyensis (Stimpson), 1855
Phallusia curvata Traustedt, 1882
Rhodosoma pellucidum (Stimpson), 1855
Botryllus (Botrylloides) niger (Herdman), 1886
Symplegma viride brakenhielmi (Michaelson), 1904
Polycarpa oblecta Traustedt, 1883
Polycarpa spongiabilis Traustedt, 1883
Styela partita (Stimpson), 1852
Styela plicata (Lesueur), 1823
Microcosmus exasperatus Heller, 1878
Microcosmus helleri Herdman, 1881
Pyura vittata (Stimpson), 1852
Molgula occidentalis Traustedt, 1883

B.—Ascidians from the former Danish West Indies (26 species and forms).

Aplidium lobatum Savigny, 1816
Aplidium (Amaroucium) bermudæ (Van Name), 1902
Trididemnum solidum (Van Name), 1902
Didemnum candidum Savigny, 1816
Leptoclinum macdonaldi (Herdman), 1886
Lissoclinum fragile (Van Name), 1902
Polycitor (Eudistoma) olivaceus (Van Name), 1902
Polycitor (Eudistoma) olivaceus form *obscuratus* (Van Name), 1902
Polycitor (Eudistoma) hepaticus, new species
Clavelina oblonga Herdman, 1880
Holozoa bermudensis (Van Name), 1902
Ecteinascidia turbinata Herdman, 1880
Phallusia nigra Savigny, 1816
Phallusia hygomiana Traustedt, 1882
Phallusia sydneyensis (Stimpson), 1855
Phallusia curvata Traustedt, 1882
[Asciidiella styeloides (Traustedt), 1882]
Rhodosoma pellucidum (Stimpson), 1855
Corella minuta Traustedt, 1882
Polycarpa oblecta Traustedt, 1883
Styela plicata (Lesueur), 1823
Microcosmus exasperatus Heller, 1878
[Microcosmus anchylodeirus Traustedt, 1883]
Pyura momus form *pallida* (Heller), 1878
Pyura vittata (Stimpson), 1852
Molgula occidentalis Traustedt, 1883

C.—Ascidians from the coasts of Florida and adjacent banks (43 species and forms).

Polychinum constellatum Savigny, 1816
Aplidium (Amaroucium) bermudæ (Van Name), 1902
Aplidium (Amaroucium) pellucidum form *constellatum* (Verrill), 1871
Aplidium (Amaroucium) exile (Van Name), 1902. (Identification not certain.)

Trididemnum savignii (Herdman), 1886
Trididemnum savignii form *porites* (Van Name), 1902
Didemnum candidum Savigny, 1816
Didemnum fusiferum, new species
Didemnum (Polysyncraton) amethysteum (Van Name), 1902
Leptoclinum macdonaldi (Herdman), 1886
Echinoclinum verrilli Van Name, 1902
Polycitor (Eudistoma) olivaceus (Van Name), 1902
Polycitor (Eudistoma) olivaceus form *obscuratus* (Van Name), 1902
Polycitor (Eudistoma) convexus (Van Name), 1902
Polycitor (Eudistoma) hepaticus, new species
Clavelina oblonga Herdman, 1880
Clavelina gigantea (Sluiter), 1919
Cystodytes dellechiaiæ (Della Valle), 1877
Holozoa bermudensis (Van Name), 1902
Holozoa bursata, new species
Rhopalæa abdominalis (Sluiter), 1898
Perophora viridis Verrill, 1871
Erteinascidia turbinata Herdman, 1880
Phallusia nigra Savigny, 1816
Phallusia hygomiana Traustedt, 1882
Phallusia curvata Traustedt, 1882
Rhodosoma pellucidum (Stimpson), 1855
Corella minuta Traustedt, 1882
Botryllus schlosseri (Pallas), 1766
Botryllus (Botrylloides) niger (Herdman), 1886
Synplegma viride brakenhielmi (Michaelsen), 1904
Polyandrocarpa maxima (Sluiter), 1904
Polyandrocarpa (Eusynstyela) floridana, new species
Polyandrocarpa (Eusynstyela) tincta (Van Name), 1902
Polycarpa oblecta Traustedt, 1883
Polycarpa circumarata (Sluiter), 1904
Styela partita (Stimpson), 1852
Styela plicata (Lesueur), 1823
Microcosmus exasperatus Heller, 1878
Pyura vittata (Stimpson), 1852
Molgula manhattensis (De Kay), 1842
Molgula occidentalis Traustedt, 1883
Bostrichobranchus pilularis (Verrill), 1871

D.—Ascidians from Bermuda (31 species and forms. The second column gives the name used for the species in my previous article (1902) on the Bermuda ascidians).

Aplidium (Amaroucium) bermudæ (Van Name),
 1902
Aplidium (Amaroucium) exile (Van Name), 1902
Trididemnum savignii (Herdman), 1886
Trididemnum savignii form *porites* (Van Name),
 1902

Amaroucium bermudæ
Amaroucium exile
Didemnum savignii + *D. atrocantum*
Didemnum porites + *D. lucidum*

PRESENT NAME	VAN NAME, 1902
<i>Trididemnum solidum</i> (Van Name), 1902	<i>Didemnum solidum</i>
<i>Trididemnum orbiculatum</i> (Van Name), 1902	<i>Didemnum orbiculatum</i>
<i>Didemnum candidum</i> Savigny, 1816	<i>Leptoclinum speciosum</i> (+ varieties)
<i>Didemnum (Polysyncraton) amethysteum</i> (Van Name), 1902	<i>Polysyncraton amethysteum</i>
<i>Leptoclinum macdonaldi</i> (Herdman), 1886	<i>Diplosoma macdonaldi</i> + <i>D. lacteum</i> + <i>D. atropunctatum</i>
<i>Lissoclinum fragile</i> (Van Name), 1902	<i>Diplosomoides fragile</i>
<i>Echinoclinum verrilli</i> Van Name, 1902	<i>Echinoclinum verrilli</i>
<i>Polycitor (Eudistoma) olivaceus</i> (Van Name), 1902	<i>Distoma olivaceum</i>
<i>Polycitor (Eudistoma) olivaceus</i> form <i>obscuratus</i> (Van Name), 1902	<i>Distoma obscuratum</i>
<i>Polycitor (Eudistoma) convexus</i> (Van Name), 1902	<i>Distoma convexus</i>
<i>Polycitor (Eudistoma) clarus</i> (Van Name), 1902	<i>Distoma clarum</i>
<i>Polycitor (Eudistoma) capsulatus</i> (Van Name), 1902	<i>Distoma capsulatum</i>
<i>Clavelina oblonga</i> Herdman, 1880	<i>Clavelina oblonga</i> + <i>Rhodozona picta</i>
<i>Cystodytes dellechiaiei</i> (Della Valle), 1877	<i>Cystodytes draschii</i> + <i>C. violaceus</i>
<i>Holozoa bermudensis</i> (Van Name), 1902	<i>Distaplia bermudensis</i>
<i>Perophora viridis</i> Verrill, 1871	<i>Perophora viridis</i>
<i>Ecteinascidia turbinata</i> Herdman, 1880	<i>Ecteinascidia turbinata</i>
<i>Phallusia nigra</i> Savigny, 1816	<i>Ascidia atra</i>
<i>Phallusia curvata</i> Traustedt, 1882	<i>Ascidia curvata</i>
<i>Botryllus (Botrylloides) niger</i> (Herdman), 1886	<i>Botrylloides nigrum</i> (+ varieties)
<i>Symplegma viride</i> Herdman, 1886	<i>Diandrocarpa botrylloides</i> + <i>Symplegma viride</i>
<i>Polyandrocarpa (Eusynstyela) tincla</i> (Van Name), 1902	<i>Michaelsenia tincla</i>
<i>Polycarpa oblecta</i> Traustedt, 1883	<i>Polycarpa oblecta</i>
<i>Styela partita bermudensis</i> (Van Name), 1902	<i>Styela partita</i> var. <i>bermudensis</i>
<i>Styela plicata</i> (Lesueur), 1823	Not recorded
<i>Microcosmus exasperatus</i> Heller, 1878	<i>Microcosmus miniatu</i>
<i>Pyura vittata</i> (Stimpson), 1852	<i>Halocynthia rubrilabia</i> + <i>H. riiseana</i> var. <i>munila</i>

ALPHABETICAL LIST OF ASCIDIANS (INCLUDING SYNONYMS) REPORTED FROM THE WEST INDIAN AND NEIGHBORING REGIONS

The synonyms included are those referring to the species as inhabitants of the region covered by this article.

Varieties and subspecies are not included (except those that have at some time been treated as full species), but are dealt with in the systematic part of this article under the species to which they belong.

Full titles of works referred to will be found in the bibliography at the end of this article.

Amarœcium. Syn. of *Amaroucium*.

Amaroucium. In this article treated as a subgenus of *Aplidium*. See species listed under *Aplidium*.

Amouroucium. Syn. of *Amaroucium*.

Aplidium lobatum. See p. 303.

" *crassum* Herdman, 1886, p. 207, Pl. xxv, figs. 15, 16. From Bahia, Brasil, in shallow water.

" (subgenus *Amaroucium*) *bermudzæ*. See p. 305.

" " " *constellatum*. See p. 310,

" " " *exile*. See p. 311.

" " " *pellucidum*. See p. 309.

" " " *stellatum*. See p. 308.

Ascidea. Syn. of *Ascidia*.

Ascidia albeola Lesueur, 1823, p. 3, Pl. II, fig. 1. From Guadeloupe. A minute, probably immature form. Genus uncertain. Hartmeyer, 1909-1911, p. 1630, assigns it to the genus *Ecteinascidia*.

" *atra* = *Phallusia nigra*.

" *cavernosa* Lesueur, 1823, p. 2, Pl. I, fig. 1. From St. Bartholomew Id. Genus uncertain. Hartmeyer (1909-1911, p. 1630) assigns it to the genus *Pyura*.

" *claviformis*. Probably either *Ecteinascidia turbinata* or *Clavelina oblonga*. See p. 379.

" *curvata* = *Phallusia curvata*.

" *interrupta*. Perhaps = *Phallusia hygomiana*. See p. 386.

" *lobifera* Lesueur, 1823, p. 7. No locality given, perhaps not West Indian. Genus uncertain.

" *longitubis* = *Phallusia sydneyensis*.

" *manhattensis* = *Molgula manhattensis*.

" *monstrans* = *Phallusia monstrans*.

" *multiformis* Lesueur, 1823, p. 3, Pl. II, figs. 2-4. From Guadeloupe. Genus uncertain. Hartmeyer (1909-1911) assigns the species *Cækira* (syn. of *Molgula*).

" *nigra* = *Phallusia nigra*.

" *ovalis* Lesueur, 1823, p. 6, Pl. III, fig. a. From the bottom of a vessel, Philadelphia. Genus uncertain. Possibly it may be *Phallusia hygomiana*.

" *plicata* = *Styela plicata*.

" *proboscidea* Lesueur, 1823, p. 6, Pl. I, figs. 4, 5. From Florida. Probably not an ascidian.

Ascidia prostrata = *Phallusia prostrata*.

" *styeloides* = *Ascidella styeloides*.

" *sydneyensis* = *Phallusia sydneyensis*.

" *variabilis* Lesueur, 1823, p. 4, Pl. II, fig. 5. From St. Thomas. Identity uncertain. Hartmeyer (1909-1911, p. 1630) assigns it to the genus *Pyura*, but it may be *Microcosmus exasperatus*.

Ascidella styeloides. This is evidently the correct genus for *Phallusia styeloides* Traustedt (1882, pp. 277, 286, Pl. IV, fig. 5; Pl. V, fig. 16) from St. Croix and St. Thomas, as it is described as having no papillæ on the internal longitudinal vessels and the intestinal loop little bent, both characters marking the genus *Ascidella* Roule, 1883.

Bollenia coacta = *Pyura legumen*.

" *coarcta* = " "

" *legumen* = " "

Bostrichobranchus pilularis. See p. 475.

Botrylloides. In this article treated as a subgenus of *Botryllus*. See species listed under *Botryllus*.

Botryllus gouldi = *B. schlosseri*.

" *gouldii* = *B. schlosseri*.

" *schlosseri*. See p. 398.

" (subgenus *Botrylloides*) *chazaliei* Sluiter, 1898, p. 10. From Marguerita Island (lagoon). Perhaps not distinct from *B. niger*.

" (subgenus *Botrylloides*) *niger*. See p. 399.

" " " *perspicuus* var. *rubicundus* (*Botrylloides perspicuum* var. *rubicundum* Herdman, 1886, p. 48, Pl. I, figs. 6, 7; Pl. III, figs. 15-18). Philippines Listed from Bermuda by Hartmeyer, 1909-1911, p. 1633, probably by mistake.

Botryorchis atlanticus = *Styela atlantica*.

Cassira. Syn. of *Molgula*. See species listed under *Molgula*.

Cellulophana collectrix = *Holozoa collectrix*.

Chondrostachys oblonga = *Clavelina oblonga*.

" *claviformis* = *Ascidia claviformis*.

" *picta* = *Clavelina oblonga*.

Ciona abdominalis = *Rhopalza abdominalis*.

Clavelina gigantea. See p. 358.

" *oblonga*. See p. 354.

" *picta* = *Clavelina oblonga*.

Clavellina. Misprint for *Clavelina*.

Colella sigillinoides = *Sycosoa sigillinoides*.

Corella eumyota Traustedt, 1882, p. 273, Pl. IV, figs. 2, 3; Pl. V, figs. 13, 14. From Bahia, Brazil, and Valparaiso, Chile, Patagonia, etc. Also South Africa, Sluiter, 1897, p. 40, Pl. V, fig. 14, and West Africa, Michaelsen, 1915, p. 423.

Corella minuta. See p. 395.

Cynthia amphora Gould, 1852, p. 495, Pl. LII, fig. 609. Rio Janeiro, Brazil, 4-5 fathoms. Genus doubtful.

" *chazaliei* = *Pyura chazaliei*.

" *claudicans* = *Microcosmus claudicans*.

" *discrepans* = *Pyura discrepans*.

Cynthia dura = *Pyura squamulosa* variety *dura*.

" *laevigata* = *Pyura vittata*.

" *nodulosa* von Drasche, 1884, p. 375. Not West Indian; = *Pyura socialis* (Troschel) 1852, from Chile and Peru.

" *pallida* = *Pyura momus* form *pallida*.

" *partita* = *Styela partita*.

" *plicata* = *Styela plicata*.

" *riiseana* = *Pyura vittata*.

" *subcaerulea* Stimpson, 1852, p. 331. From Oak Id. Beach, North Carolina. A small and perhaps immature form. Genus doubtful. See p. 419.

" *torpida* = *Pyura torpida*.

" *vittata* = *Pyura vittata*.

Cystodites. Syn. of *Cystodytes*.

Cystodytes dellechiaiei. See p. 360.

" *dellechiaiei* = *C. dellechiaiei*.

" *draschei* = *C. dellechiaiei*.

" *draschii* = *C. dellechiaiei*.

" *violaceus* = *C. dellechiaiei*.

Diandrocarpa botryllopsis = *Symplegma viride*.

" *brakenhielmi* = *Symplegma viride brakenhielmi*.

Diazona picta = *Clavelina oblonga*.

" *geayi* Caullery, 1914, Bull. Soc. Zool. France, XXXIX, p. 204, figs. 1, 2. From French Guiana. Perhaps a *Clavelina*.

Didemnopsis inermis = *Didemnum inermis*.

Didemnum amethysteum. See p. 333.

" *annectens* (*Leptoclinum annectens* Herdman, 1886, p. 280, Pl. xxxiv, fig. 14; Pl. xxxviii, figs. 5-9). From Bahia, Brazil, shallow water. Perhaps not distinct from *D. candidum*.

" *atrocanum* = *Trididemnum savignii*.

" *candidum*. See p. 323.

" *cineraceum* (*Leptoclinum cineraceum* Sluiter, 1898, p. 30, Pl. II, figs. 41 41a; Pl. III, fig. 48). Kingston, Jamaica.

" *conchyliatum* (*Leptoclinum conchyliatum* Sluiter, 1898, p. 29, Pl. III, fig. 47). From Curaçao and Jamaica (Kingston).

" *fusiferum*. See p. 331.

" *inermis* Herdman, 1886, p. 265, Pl. xxxiv, figs. 6, 7. From Bermuda. Described from very poor specimens. Genus and family very doubtful.

" *lucidum* = *Trididemnum savignii* form *porites*.

" *lutarium* = *D. candidum* *lutarium*. See p. 323.

" *orbiculatum* = *Trididemnum orbiculatum*.

" *porites* = *Trididemnum savignii* form *porites*.

" *solidum* = *Trididemnum solidum*.

" *savignii* = *Trididemnum savignii*.

" *savignyi* = *Trididemnum savignii*.

" *speciosum* = *D. candidum*.

" *studerii*. Not West Indian. See p. 331.

" *tenuis* (*Leptoclinum tenue* Herdman, 1886, p. 281, Pl. xxxix, figs. 8-11; Pl. XL, figs. 3-5). Sluiter, 1898, p. 31, reports this from Los Testigos Islands. It would seem much more likely that Sluiter's specimens were *D. candidum*.

Didemnum (subgenus *Polysyncrator*) *amethysteum*. See p. 333.

Diplasoma. Misprint for *Diplosoma*.

Diplosoma atropunctatum = *Leptoclinum macdonaldi*.

" *lacteum* = *Leptoclinum macdonaldi*.

" *macdonaldi* = *Leptoclinum macdonaldi*.

Diplosomoides. Syn. of *Lissoclinum*. See species under *Lissoclinum*.

Distalium. Misprint for *Distaplia*.

Distaplia. Syn. of *Holozoa*. See species under *Holozoa*.

Distoma. Syn. of *Polycitor*. See species under *Polycitor*.

Echinoclinum verrilli. See p. 340.

Ecteinascidia albeola. = *Ascidia albeola*.

" *thurstoni*. Not West Indian. See p. 379.

" *turbinata*. See p. 375.

Eudistoma. Subgenus of *Polycitor*, sometimes given rank of a genus. See species under *Polycitor*.

Eusynstyela. Here treated as a subgenus of *Polyandrocarpa*. See species under *Polyandrocarpa*.

Halocynthia microspinosus = *Tethyum microspinosum*.

" *pallida* = *Pyura momus* form *pallida*.

" *riseana* = *Pyura vittata*.

" *rubrilabia* = *Pyura vittata*.

Holozoa bermudensis. See p. 363.

" *bursata*. See p. 366.

" *collectrix* (*Cellulophana collectrix* O. Schmidt, 1870, p. 25). See p. 365.

Leptoclinum annectens = *Didemnum annectens*.

" *atropunctatum* = *L. macdonaldi*.

" *cineraceum* = *Didemnum cineraceum*.

" *conchyliatum* = *Didemnum conchyliatum*.

" *lacteum* = *L. macdonaldi*.

" *macdonaldi*. See p. 335.

" *speciosum* = *Didemnum candidum*.

" *tenuis* = *Didemnum tenue*.

Lissoclinum fragile. See p. 338.

" *molle*. See p. 339.

Michaelsenia tinctoria = *Polyandrocarpa (Eusynstyela) tinctoria*.

Microcosmus anchylodeirus Traustedt, 1883, pp. 121, 133, Pl. vi, fig. 18. From St. Thomas. Michaelsen, 1919, pp. 58, 62 considers this possibly identical with *M. pupa* Savigny, 1816, from the Red Sea. See p. 466.

" *biconvolutus* Sluiter, 1898, p. 26, Pl. ii, figs. 36-38. From Curaçao.

" *claudicans* (*Cynthia claudicans* Savigny, 1816, p. 150, Pl. ii, fig. 1). Reported by Heller, 1878, pp. 83, 84, as probably occurring in the Antilles. It is more likely that his specimens were *M. exasperatus*.

" *distans* = *M. exasperatus*.

" *exasperatus*. See p. 459.

" *helleri*. See p. 463.

" *miniatus* = *M. exasperatus*.

" *pupa*. See under *M. anchylodeirus*.

" *variegatus* = *M. exasperatus*.

Molgulina contorta = *Molgula contorta*.

" *eugyroides* = *Molgula eugyroides*.

Molgula contorta Sluiter, 1898, p. 28, Pl. II, figs. 39, 40. From Rio Hacha, Goajira, Colombia. Related to *M. eugyroides*.

" *eugyroides* Traustedt, 1883, p. 112, Pl. v, figs. 1-3. From Bahia, Brazil. Hartmeyer (1914) has made this species the type of a genus, *Molgulina*, the branchial sac showing an approach to the condition found in the genus *Eugyra*, having large regularly placed infundibula with long spiral stigmata.

" *koreni*. Credited to the West Indies by mistake (Herdman), 1891.

" *lutulenta*. See p. 474.

" *manhattensis*. See p. 471.

" *multiformis* = *Ascidia multiformis*.

" *occidentalis*. See p. 467.

" *pellucida*. See p. 476.

" *sordida* Stimpson, 1852, p. 229. From rocks off the breakwaters of Charleston, S. C., Harbor. Insufficiently described, but probably = *M. manhattensis*. Not *M. sordida* Sluiter, 1904, which is from the Malay region.

" *tenax* = *M. papillosa* Verrill, 1871. Credited to the West Indies by Herdman, 1891, by mistake.

Pandocia. Syn. of *Polycarpa*. As used by Sluiter, it ranks as a subgenus of *Styela*. See species under *Polycarpa*.

Perophora viridis. See p. 373.

Phallusia atra = *Ph. nigra*.

" *atrales*. Misprint for *Ph. atra*.

" *canaliculata* = *Phallusia sydneyensis*.

" *curvata*. See p. 389.

" *interrupta* (*Ascidia interrupta*, Heller, 1878, p. 89, Pl. II, fig. 9). From Jamaica. Perhaps the same as *Ph. hygomiana*.

" *hygomiana*. See p. 383.

" *longitubis* = *Ph. sydneyensis*.

" *monstrans* (*Ascidia monstrans* Gould, 1852, p. 496, Pl. LII, fig. 611). From near entrance of harbor, Rio Janeiro, Brazil, in 3 fathoms, attached to old shells, etc.

" *nigra*. See p. 379.

" *prostrata* (*Ascidia prostrata* Heller, 1878, p. 90, Pl. I, fig. 4). From Jamaica.

" *styeloides* = *Ascidella styeloides*.

" *sydneyensis*. See p. 386.

Phallusiopsis nigra = *Phallusia nigra*.

Polyandrocarpa maxima. See p. 412.

" *sabanilla*. See p. 409.

" (subgenus *Eusynstyela*) *floridana*. See p. 417.

" " " *tincta*. See p. 414.

Polycarpa appropinquata (*Styela*, subgenus *Polycarpa*, *appropinquata* Sluiter, 1898, p. 18, Pl. I, figs. 19-21). From La Tortuga Id., Venezuela.

" *asiphonica* (*Styela*, subgenus *Polycarpa*, *asiphonica* Sluiter, 1898, p. 17, Pl. I, figs. 16-18). From Goajira, Rio Hacha, Colombia, 6-7 meters.

" *brevipedunculata* (*Styela*, subgenus *Polycarpa*, *brevipedunculata* Sluiter, 1898, p. 15, Pl. I, fig. 12). From Curaçao.

Polycarpa cartilaginea (*Styela*, subgenus *Polycarpa*, *cartilaginea* Sluiter, 1898, p. 16, Pl. I, figs. 13-15). From Gairaca and Santa Marta, Colombia. Apparently related to *P. oblecta*.

" *circummarata*. See p. 428.

" *fibrosa*. See p. 296.

" *friabilis* (*Styela*, subgenus *Polycarpa*, *friabilis* Sluiter, 1898, p. 13, Pl. I, fig. 11). From Jamaica (Kingston). Apparently related to *P. oblecta*.

" *fuliginea* (*Styela*, subgenus *Polycarpa*, *fuliginea* Sluiter, 1898, p. 12, Pl. I, fig. 10; Pl. III, fig. 45). From near the Tortugas Ids., 45 meters. (Probably La Tortuga, Venezuela is meant.)

" *insulsa* (*Styela*, subgenus *Polycarpa*, *insulsa* Sluiter, 1898, p. 14, Pl. III, fig. 43). From Los Testigos Ids.

" *nivosa* (*Styela*, subgenus *Polycarpa*, *nivosa* Sluiter, 1898, p. 12, Pl. I, fig. 9; Pl. III, fig. 46). Santa Marta, Colombia, 30 meters.

" *oblecta*. See p. 420.

" *pilella* Herdman, 1881, p. 73; 1882, p. 174, Pl. xxii, figs. 11-15. From Bahia, Brazil, 7-20 fathoms. (Not *P. pilella* Herdman, 1899, from Australia, according to Michaelsen, 1912).

" *rugosa* von Drasche, 1884, p. 380, Pl. vii, figs. 3, 4. From Rio Janeiro, Brazil. Apparently related to *P. oblecta*.

" *seminuda* (*Styela*, subgenus *Polycarpa*, *seminuda* Sluiter, 1898, p. 19, Pl. II, figs. 22, 23). From La Tortuga Id., Venezuela. 45 meters. Apparently related to *P. oblecta*.

" *spongiabilis*. See p. 424.

" *tumida* Heller, 1878, p. 103, Pl. II, fig. 15. Probably the same as *P. oblecta*.

Polycitor (*Eudistoma*) *capsulatus*. See p. 352.

" " *clarus*. See p. 350.

" " *convexus*. See p. 346.

" *giganteus* = *Clavelina gigantea*.

" (*Eudistoma*) *mayeri* = *P. convexus*.

" " *hepaticus*. See p. 348.

" " *obscuratus* = *P. (E.) olivaceus* form *obscuratus*. See p. 345.

" " *olivaceus*. See p. 343.

Polyclinum constellatum. See p. 299.

Polysyncraton amethysteum = *Didemnum* (subgenus *Polysyncraton*) *amethysteum*.

Psammaphidium funginum Sluiter, 1898, p. 31. From La Tortuga Id.

Puyra. Misprint for *Pyura*.

Pyura amphora = *Cynthia amphora*.

" *antillarum*. See p. 451.

" *cavernosa* = *Ascidia cavernosa*.

" *chazaliei* (*Cynthia chazaliei* Sluiter, 1898, p. 22, Pl. II, figs. 29, 30. From Santa Marta, Colombia.

" *coacta* = *P. legumen*.

" *discrepans* (*Cynthia discrepans* Sluiter, 1898, p. 23, Pl. II, figs. 31-34; Pl. III, fig. 44). From Gulf of Cariaco, Santa Maria, Colombia, and Kingston, Jamaica.

" *dura* = *P. squamulosa* variety *dura*.

" *lævigata* = *P. vittata*.

Pyura legumen (Lesson), 1830; Hartmeyer (1909-1911, pp. 1629-1632), indicates that *Bollenia coacta* Gould, 1852, p. 496. Atlas, p. 16, Pl. LI, fig. 212, which is evidently identical with this species, was from the Gulf of Mexico. Gould, however, gives the locality Orange Harbor (Terra del Fuego). The species is sub-antarctic in distribution, and its occurrence in the Gulf of Mexico seems very improbable.

" *momus* form *pallida*. See p. 454.

" *pallida*. = *P. momus* form *pallida*.

" *riiseana* = *P. vittata*.

" *rubrilabia* = *P. vittata*.

" *squamulosa* variety *dura* Heller, 1878, p. 83 (probably incorrectly) reports this Mediterranean form from the Antilles and New Zealand under the name *Cynthia dura*.

" *torpida* (*Cynthia torpida* Sluiter, 1898, p. 21, Pl. II, figs. 25-28). From Santa Marta, Colombia.

" *variabilis* = *Ascidia variabilis*.

" *vittata*. See p. 446.

Pyuræ. Misprint for *Pyura*.

Rhabdocynthia pallida = *Pyura momus* form *pallida*.

Rhodosoma pellucidum. See p. 392.

" *pyxis* = *Rh. pellucidum*

" *seminudum* = *Rh. pellucidum*

Rhodozona picta = *Clavelina oblonga*.

Stereoclavella oblonga = *Clavelina oblonga*.

Styela atlantica. See p. 440.

" *appropinquata* = *Polycarpa appropinquata*.

" *asiphonica* = *Polycarpa asiphonica*.

" *brevipedunculata* = *Polycarpa brevipedunculata*.

" *canopoides* = *Styela partita*.

" *cartilaginea* = *Polycarpa cartilaginea*.

" *friabilis* = *Polycarpa friabilis*.

" *fuliginea* = *Polycarpa fuliginea*.

" *insulsa* = *Polycarpa insulsa*.

" *nivosa* = *Polycarpa nivosa*.

" *partita*. See p. 431.

" *plicata*. See p. 435.

" *seminuda* = *Polycarpa seminuda*.

Stygela. Misprint for *Styela*.

Sycozoa sigillinoides (Lesson), 1870. A colony of this species reported floating off the coast of Rio Grande del Norte, Brazil, by Michaelsen, 1907, p. 47. It had doubtless drifted from much farther south, and cannot be regarded as belonging to the fauna of this region.

Symplegma viride. See p. 404.

" *brakenhielmi* = *Symplegma viride brakenhielmi*. See p. 407.

Tethyum atlanticum = *Styela atlantica*.

" *canopoides* = *Styela partita*.

" *microspinosum*. See p. 441.

" *partitum* = *Styela partita*.

Tethyum plicatum = *Styela plicata*.

Thallusia. Misprint for *Phallusia*.

Tolycitor. Misprint for *Polycitor*.

Trididemnum atrocanum = *T. savignii*.

" *lucidum* = *T. savignii* form *porites*.

" *orbiculatum*. See p. 320.

" *porites* = *T. savignii* form *porites*. See p. 317.

" *savignii*. See p. 314.

" *savignyi* = *T. savignii*.

" *solidum*. See p. 318.

Tunica nigra = *Phallusia nigra*.

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Article XVII.—A REVIEW OF THE DIVING PETRELSCONTRIBUTIONS FROM THE BREWSTER-SANFORD COLLECTION.—3¹

BY ROBERT CUSHMAN MURPHY AND FRANCIS HARPER

PLATES XX TO XXIV

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INTRODUCTION

The diving petrels (*Pelecanoididæ*) comprise a strikingly homogeneous, monogeneric, obviously ancient group of *Tubinares*, the members of which exhibit few characters that might indicate their relationships with other divisions of the order. They have therefore always presented a difficult problem to taxonomists. Confined entirely to the southern hemisphere, where they have long been pointed out as biological analogues of the auklets and murrelets of the north, the *Pelecanoididæ* have become distributed through a broad south temperate and subantarctic belt, one species alone having extended its range northward along the west coast of America into the tropics.

¹First contribution, 1917, 'A New Albatross from the West Coast of South America,' *Bull. Amer. Mus. Nat. Hist.*, XXXVII, pp. 861-864. Second contribution, 1918, 'A Study of the Atlantic *Oceanites*,' *Bull. Amer. Mus. Nat. Hist.*, XXXVIII, pp. 117-146.

Five species, representing four subgenera, are recognizable among the numerous specimens studied by the writers. Relatively speaking, the distinctions between the subgenera are subtle, if not slight. When we add to this the facts that reasonably large series of properly prepared specimens have never until within the last few years been brought together, and that the ranges of two species have been found to be of extraordinary extent, it is not surprising that the specific and geographic status of the various representatives has been so generally misunderstood. So able a systematist as Dr. Coues wrote in 1866 that the three species which he provisionally recognized might "without great violence" be considered as extremes of a single very variable type. This investigator's material, however, was doubtless insufficient for him to appreciate certain structural characters of the bill upon which the current classifications are largely based. It is noteworthy that two of the forms to which Coues referred have, by both a previous and a later authority, been relegated to different genera.

MATERIAL AND ACKNOWLEDGMENTS

Approximately 500 specimens of *Pelecanoididæ* in American collections, and 100 specimens in European collections, have been examined by the writers in the preparation of the present review. Of this number, one hundred and eighty-seven skins, belonging to the Brewster-Sanford Collection, were taken in Peru, Chile, the Fuegian region, and the Falkland Islands by Mr. R. H. Beck, between 1913 and 1915. Two hundred and forty-six skins, comprising the type and topotypes of a newly described species, were collected in the breeding seasons of 1912, 1913, and 1914, at the island of South Georgia, by the senior writer and by Mr. Joseph G. Correia, of New Bedford, Massachusetts. Specimens of the Old World diving petrels are still regrettably scarce in American museums, but we have had at our disposal the skins collected at Kerguelen Island by Dr. Kidder in 1872, besides a small series of birds from New Zealand and its outliers.

Our hearty thanks for the loan of material are due the following institutions and individuals: the United States National Museum, through Dr. Charles W. Richmond; the Philadelphia Academy of Natural Sciences, through Dr. Witmer Stone; the Museum of Comparative Zoology, through Mr. Outram Bangs; the Carnegie Museum, through Mr. W. E. Clyde Todd; the Boston Society of Natural History, through Mr. W. Sprague Brooks; the Michigan University Museum, through Dr. Alexander G. Ruthven; the Public Museum of Milwaukee, through

Mr. Henry L. Ward; the California Academy of Sciences, through Dr. Barton W. Evermann; and Mr. James H. Fleming, of Toronto.

In May 1919, after this paper was already in proof, the junior writer was enabled to make a brief visit to several museums in England and France, and to examine there a large amount of especially interesting material pertinent to the present study. This material included the types or type series of six described forms of *Pelecanoididæ* (*Puffinuria garnotii lessoni* Mathews, *Puffinuria garnotii magellani* Mathews, *Pelecanoides urinatrix belcheri* Mathews, *Pelecanoides exsul* Salvin, *Pelecanoides dacunhæ* Nicoll, and *Pelecanoides urinatrix coppingeri* Mathews), two of which are not represented by topotypes in American collections. Many courtesies and facilities were extended by Mr. Charles Chubb and Mr. David A. Bannerman, of the British Museum, by Mr. Gregory M. Mathews, of the Austral Avian Museum, by Dr. Ernst Hartert, of the Zoological Museum, Tring, and by Dr. E.-L. Trouessart, of the Museum National d'Histoire Naturelle, Paris, to all of whom we are glad to acknowledge our indebtedness and express our appreciation. The results of our all too brief studies in these institutions have been incorporated in the present work.

We are also much indebted to Dr. Frank M. Chapman and Dr. W. D. Matthew, of The American Museum of Natural History, for reading the manuscript; to Dr. R. E. Coker, of the United States Bureau of Fisheries, for placing at our disposal his account of *Pelecanoides garnoti* in advance of its publication in his paper on the guano birds of Peru¹; to Dr. Harry C. Oberholser, of the United States Biological Survey, for helpful advice and criticism during the course of our investigations; and to Mr. James P. Chapin, of The American Museum of Natural History, for making the sectional drawing of the bill of *Pelecanoides garnoti* which is reproduced in Fig. 1.

HISTORY

The early history of the nomenclature of the diving petrels is summarized by Mathews in the 'Birds of Australia,' II, pp. 232-239. The important steps in the successive discoveries, descriptions, and revisions are listed and brought up to date below.

1789. GMELIN ('Syst. Nat.,' p. 560) founded the species *Procellaria urinatrix* from the description in Latham's Synopsis, which was in turn based upon Forster's drawing made from a specimen taken in Queen Charlotte Sound, New Zealand.

¹1919, Proc. U. S. Nat. Mus., LVI, pp. 440-511.

1824. QUOY AND GAIMARD ('Voy. Uranie et Physicienne, Zool.,' p. 135, Pl. xxxvii) described and figured *Procellaria berard* from a specimen which came on board their vessel near the Falkland Islands.

1828. LESSON ('Manuel d'Orn.,' II, p. 394) described *Puffinuria garnoti* from birds taken on the coast of Peru. In the same year the species was figured ('Voy. Coquille,' Pl. xlvi).

After 1828, as Mathews remarks, the various names were confusedly used for many years. The specific term *urinatrix* was at times employed for all the forms; *berard* was applied to breeding birds of New Zealand and elsewhere; even Forster's *nomen nudum*, *Procellaria tridactyla*, was revived for the New Zealand bird.

1866. COUES (Proc. Phil. Acad. Sci., pp. 188-190) published a thorough structural description of the genus and, without having seen sufficient material to be fully confident of his own judgment, he admitted three species—*garnoti*, of the west coast of South America, *urinatrix*, of "Australian Seas," and *berardi*, of the highly indefinite "Southern Oceans." Coues evidently recognized only distinctions in size among the diving petrels, for he held the opinion "that the colors of the plumage of all three are identical."

1896. SALVIN ('Cat. Birds Brit. Mus.,' XXV, pp. 437-439). A reconsideration of the material and literature was undertaken by Salvin in his monograph. He synonymized *P. berard* with *P. urinatrix*, giving the range of the species as "Australian and New Zealand Seas; also those of Cape Horn and the Falkland Islands." At the same time he proposed a new species, *P. exsul*, from the southern Indian Ocean, a range bounded on both sides by that of his revised *urinatrix*.

1906. NICOLL (Bull. Brit. Orn. Cl., XVI, p. 103) added to the list of described species *Pelecanoides dacunhæ*, based upon examples collected at the island of Tristan da Cunha, in the South Atlantic.

1907. REICHENOW ('Deutsche Südp. Exp.,' IX, Zool., pp. 493, 558) united *exsul* with *urinatrix* on the ground that birds answering Salvin's description of each species are found in the same breeding localities.

1910. GODMAN ('Monogr. Petrels,' pp. 299-306) treated the taxonomic status of the diving petrels in an exceedingly casual and uncritical manner and, so far as can be judged from his textual descriptions, the titles for his largely conventional colored plates of *P. urinatrix* and *P. exsul* have been transposed! Godman was unable to perceive any difference between New Zealand specimens and those from the extremesouth of South America; neither could he distinguish between *exsul* and

dacunhæ, which he accordingly synonymized. Finally, he questioned the specific distinctness of *urinatrix* and *exsul* but provisionally recognized the latter, while fully accepting *urinatrix* and *garnoti*.

1912. MATHEWS ('Birds of Australia,' II, pp. 232-239) reviewed the whole subject, as far as the literature is concerned, and recognized *exsul*, *dacunhæ*, and *berard*, as geographic races of typical *Pelecanoides urinatrix* of the "Australian and New Zealand seas." He gave, however, no tables of measurements or other cogent reasons for accepting these subspecies, merely grouping them in a convenient geographical way and saying that they are "determinable." In the same place he created a new name, *P. urinatrix coppingeri*, for a diving petrel from the "Straits of Magellan."

Furthermore, Mathews revived Lesson's genus *Puffinuria* for the large diving petrel of the west coast of South America, giving, on pages 232 and 233 of the work cited, his reasons for this step. In this genus he placed *P. garnotii garnotii*, from Peru; *P. garnotii lessoni*, from Chile; and *P. garnotii magellani* from the Strait of Magellan; the last two forms being described as new.

1912. MATHEWS (Austral Avian Rec., p. 84) separated the Australian diving petrel as *Pelecanoides urinatrix belcheri*.

1916. MURPHY AND HARPER (Bull. Amer. Mus. Nat. Hist., XXXV, pp. 65-67) described a new subspecies, *P. u. chathamensis*, from the Chatham Islands, and a new species, *P. georgica*,¹ from South Georgia in the subantarctic Atlantic.

1918. LOOMIS, in his 'Review of the Albatrosses, Petrels, and Diving Petrels' (Proc. Calif. Acad. Sci., (4) II, part 2, No. 12, pp. 66, 67), recognized but two species, *urinatrix* and *garnoti*.

CRITICAL NOTES ON THE GENUS *PELECANOIDES*

Salvin's synopsis of the family Pelecanoididae (*loc. cit.*, p. 342) contains the statement, since universally accepted, that the "second" primary is slightly the longest. According to the modern method of quill enumeration, the vestigial, outermost flight feather of Tubinares is reckoned as the eleventh; the "second" primary of Salvin's system is therefore equivalent to the ninth. Examination of our material, however, does not support Salvin's statement. In the hundreds of specimens that have passed through our hands, the tenth (outermost functional—"first") primary is the longest whenever the quills have attained full

¹Properly *georgicus*.

growth. In this feature the diving petrels therefore agree with all other members of the order except the *Thalassidrominæ* and *Oceanitinæ*.

Coues (*loc. cit.*, p. 189) apparently based his succinct structural description of the group¹ entirely upon specimens of *Pelecanoides garnoti*, but with minor exceptions it would apply to the genus as extended in the present paper.

Mathews ('Birds of Australia,' II, p. 232) published the following as justification for the establishment of a second genus, *Puffinuria*.

I would here only note the differences between the species *P. urinatrix* and *P. garnoti* in that feature [the bill]. The former has the nostrils elongate, narrow and parallel the distensible sac contained by the rami of the under-mandible is pronounced and unfeathered [*sic*]. The latter has a longer bill with the nostrils less elongate proportionately, and more triangular shaped, with a noticeable projection from the inner edge; this can also be seen in the preceding species, but it is very minute. In addition the rami of the lower mandible do not enclose a wide distensible sac, which is also partly feathered. . . I consider that the genus *Puffinuria* should be recognized.

The formation of the nostrils in the two proposed genera is further illustrated by line drawings.

In spite of the obscure wording, Mathews has here called attention to characters of taxonomic significance. As a critique of his remarks, however, we offer the following observations: (1) specimens before us, representing *Pelecanoides exsul* from Kerguelen Island and subspecies of *Pelecanoides urinatrix* from the Chatham Islands and the Falklands, have the distensible sac between the rami feathered for more than half its length; (2) the bill of the newly-described species, *Pelecanoides georgicus*, which was unknown to Mathews, is in some respects structurally intermediate between those of *urinatrix* and *garnoti*, the nostrils being shorter and less closely appressed than those of *urinatrix*, but not so widely spread posteriorly as in *garnoti*. In its inferior aspect, the bill

¹Coues' characterization is as follows:

"The perfectly vertical nostrils are surrounded by an elevated wall, whose contour, in consequence of a slight emargination posteriorly, and a corresponding protuberance anteriorly, on the median line, is somewhat cordiform. The wall has considerable thickness basally; but much bevelling superiorly gives it an extremely thin edge. The internasal septum is moderately thick; and from either side a process projects transversely into the nasal orifice. In shape each nostril is suboval; being somewhat elongated anteriorly, and a straightening of its inner border being produced by their mutual apposition. The dertrum or unguis is long, reaching quite to the nostrils; and, for this family, is only moderately uncinated. Except at its extreme base it is distinctly carinated, and its sides are much compressed.

"The myxa is unusually small and narrow, with a very acute tip, and extremely concave gonys. The sulci separating the myxotheca from the rest of the mandible, and the lateral one on the gnathidia are strongly marked.

"The unusual amount of divarication of the concavo-convex gnathidia, which causes so wide a submentum, is, in the upper mandible, accompanied by a corresponding dilation of the lateral elements; which latter are also turgid and inflated.

"The tarsus is excessively compressed, and at the same time very deep antero-posteriorly; giving to its transverse section a narrowly elliptical shape, like that which obtains in the *Colymbidæ*. It is reticulated as in the *Procellariidæ*, and also the majority of the *Alcidæ*, though *Mergulus* has anteriorly transverse imbricated scales. The proportions of the anterior toes are as in the other *Procellariidæ*."

of *georgicus* is more broadly wedge-shaped than that of any of its congeners, though it is built on the fundamental plan of the *garnoti* bill with diverging instead of parallel rami. The lateral flanges of the internasal septum are larger in *georgicus* than in *urinatrix*, and they extend farther anteriorly, i.e., to the axial center of the nostril as in *garnoti*.

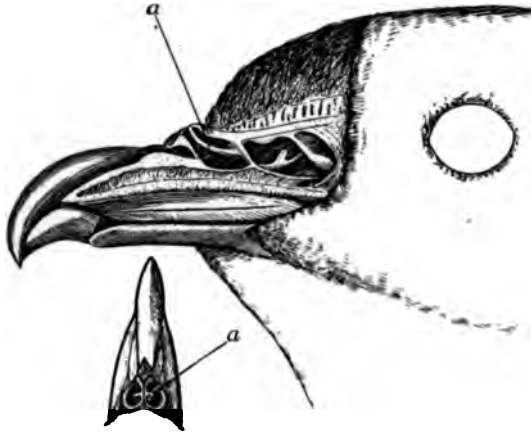


Fig. 1. Sagittal section through the left narial passage, and dorsal view of the bill, of *Pelecanoides garnoti*, showing the paraseptal process (a).

These narial flanges, which are referred to by both Coues and Mathews, are apparently peculiar to the Pelecanoididæ among Tubinæres. We can find no trace of them in *Puffinus*, *Pterodroma*, or a dissected embryo albatross (*Diomedea exulans*). They may represent an accessory fold of the anterior concha vestibuli; they differ, of course, from the folds on the nasoturbinals in lacking olfactory epithelium, being covered quite to their bases with the black, horny integument of the naricorn. Probably they are neomorphs in the Pelecanoididæ, and it may be assumed from their construction that they function in breaking up the stream of water which must tend to force its way into the nostrils during the bird's plunge from flight. A related specialization for diving habits is obvious in the upwardly directed nostrils, and it is significant that the species with the largest and widest nostrils has the best developed flanges. In view of the uncertain homologies of these flanges, they may be called "paraseptal processes." Their appearance and extent are shown in the accompanying illustrations.

The development and position of the anterior ends of the paraseptal processes, which project visibly into the nostrils, vary markedly in the

several representatives of the family. The condition in several species and subspecies is portrayed, along with other morphological details of the bill, in figure 3.

SYNOPSIS OF THE SUBGENERA OF *PELECANOIDES*

The structural intergradations mentioned above are, in our opinion, sufficient to bridge any supposed generic demarcation between *Pele-*

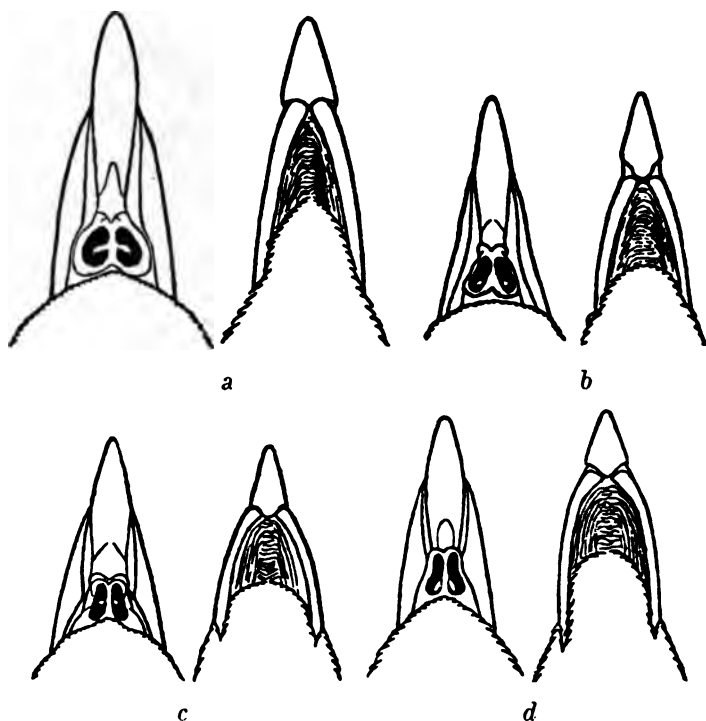


Fig. 2. Dorsal and ventral aspects of the bills of four subgenera of *Pelecanoididae*, drawn to scale but enlarged: a, *Puffinuria* (*Pelecanoides garnoti*); b, *Porthmornis* (*Pelecanoides magellani*); c, *Pelagodyptes* (*Pelecanoides georgicus*); d, *Pelecanoides* (*Pelecanoides urinatrix berard*). See also Plate XXII, fig. 2.

canoides and "*Puffinuria*," the species of which are so essentially alike in the sum of their characters. Nevertheless, since certain combinations of characters, including particularly the architecture of the bill, and to a lesser extent, the proportions of wing, tail, metatarsus, and toes, appear to represent more than specific distinctions among the diving petrels, the names *Pelecanoides* and *Puffinuria*, together with two additional names here proposed for the first time, may be applied subgenerically.

1.—Bill relatively slender in proportion to length (exposed culmen exceeding twice the width of bill at base), the sides tapering gradually from base to tip. Mandibular rami diverging from the gonys at a very acute angle, enclosing a narrow, sharply pointed interramal space. Outline of combined nasal orifices broad and cordate, the walls of the tubes horny and firm, the nostrils appressed. Anterior end of paraseptal process strongly developed and projecting prominently into middle of nostril. Claws relatively blunt and stout; claw of middle toe shorter than third phalanx; claw on inner toe not extending beyond base of claw on middle toe. Tail less than twice the length of exposed culmen, and but slightly longer than tarsus. Wing more than three and one-half times as long as tail. *Puffinuria*.

2.—Bill relatively slender in proportion to length (exposed culmen about equal to twice the width of bill at base), the sides tapering gradually from base to tip. Mandibular rami diverging at a very acute angle, as in subgenus *Puffinuria*. Outline of combined nasal orifices broad and cordate, but the walls of the tubes moderately thin and often warped somewhat in dried skins; nostrils widely divergent posteriorly. Anterior end of paraseptal process weakly developed, inconspicuous, and projecting only into posterior part of nostril. Claws relatively sharp and slender; claw of middle toe shorter than third phalanx; claw on inner toe not extending beyond base of claw on middle toe. Tail more than twice the length of exposed culmen, and one-third longer than tarsus. Wing less than three and one-half but more than three times as long as tail. *Porthmornis*,¹ new subgenus.

3.—Bill relatively broad in proportion to length (width at base equal to three-fifths of exposed culmen), the sides tapering sharply from base to tip. Mandibular rami diverging at a relatively wide angle, enclosing a short, broad interramal space. Nasal eminence thin-walled, the shape of the oval, closely appressed nostrils in dried skins always more or less altered by shrinking. Anterior end of paraseptal process strongly developed, and projecting almost as prominently into middle of nostril as in subgenus *Puffinuria*. Claws relatively sharp and slender; claw of middle toe longer than third phalanx; claw on inner toe extending beyond base of claw on middle toe. Tail more than twice the length of exposed culmen, and one-third longer than tarsus. Wing not more than three times as long as tail. *Pelagodyptes*,² new subgenus.

4.—Bill relatively stout and blunt, tapering abruptly near the tip, but almost as wide in the middle as at the base owing to the expansion of the lateral elements of the maxilla and the bowing of the mandibular rami (exposed culmen about equal to twice the width of bill at base). Rami nearly parallel for the greater part of their length, but converging abruptly toward the tip, enclosing an obtusely pointed interramal space. Myxa proportionately shorter and smaller than in any of the other subgenera. Nasal eminence thin-walled, the shape of the elongate, reniform, closely appressed nostrils in dried skins always more or less altered by shrinking. Anterior end of paraseptal process weakly developed, inconspicuous, and projecting only into posterior part of nostril. Claws relatively sharp and slender; claw of middle toe shorter than third phalanx; claw on inner toe not extending beyond base of claw on middle toe. Tail more than twice the length of exposed culmen, and at least one-fourth longer than tarsus. Wing more than three but less than three and one-half times as long as tail. *Pelecanoides*.

¹πορθμός, a strait + όρνις, bird.

²πéλαγος, the open sea + όύκτης, a diver.

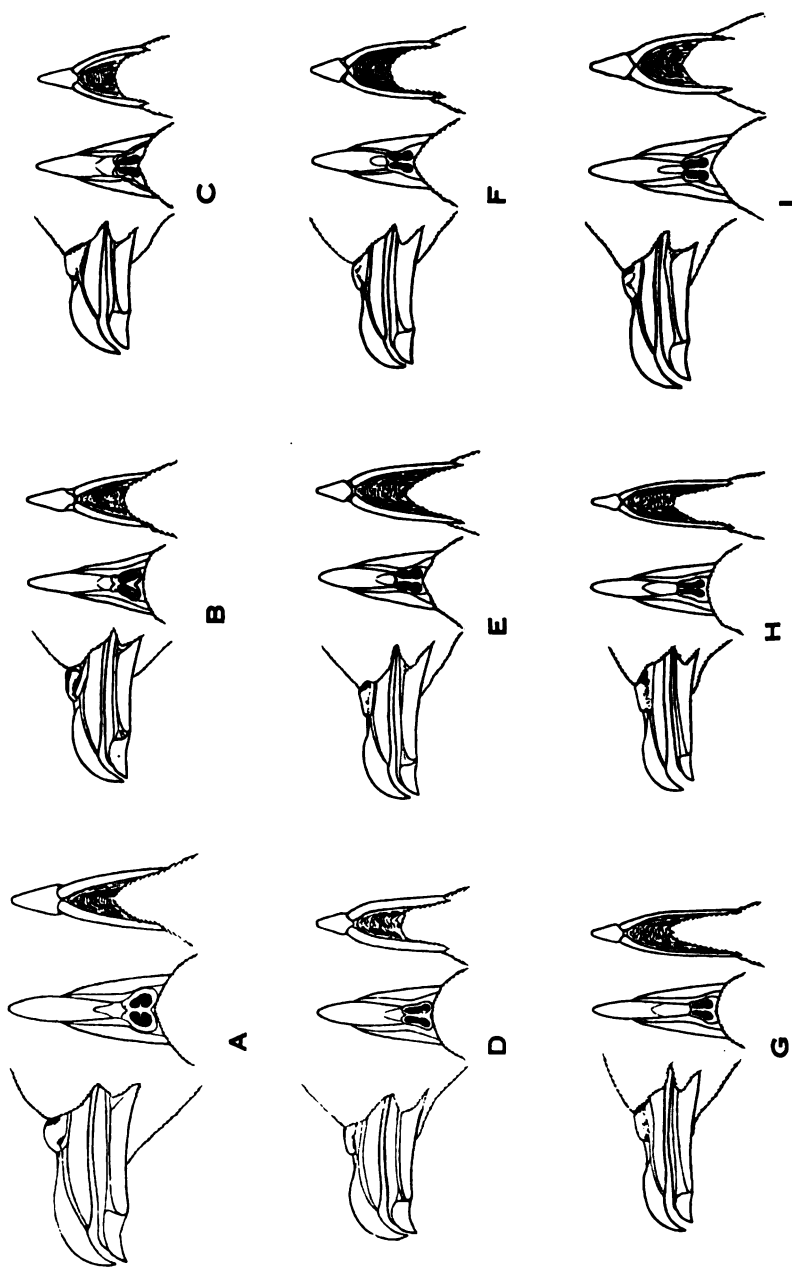


Fig. 3. Bills of nine species and subspecies of Pelicanus, drawn from adult specimens: all figures life-size, A, *P. urinator*; B, *P. magellanus*; C, *P. georgicus*; D, *P. urinator urinator*; E, *P. urinator ducula*; F, *P. urinator ducula*; G, *P. urinator ducula*; H, *P. urinator ducula*; I, *P. urinator ducula*.

SYSTEMATIC ACCOUNT OF THE SPECIES AND SUBSPECIES

In the pages that follow, the writers aim to establish the taxonomic status and the approximate geographic ranges of five species of diving petrels, namely *Pelecanoides garnoti*, *magellani*, *georgicus*, *exsul*, and *urinatrix*, representing four different subgenera. At the same time, we are aware that a great amount of work remains to be done in the way of studies of the life histories of the Pelecanoididæ, researches into genetic relationships, revisions of certain forms at present weakly represented in American collections, and perhaps the discovery of undescribed races at imperfectly explored, subantarctic islands. The various subspecies will be treated as critically as the material at our disposal permits, but a final revision of the races of *urinatrix* is a task that must await an ornithologist who enjoys the opportunity to study larger series of skins from the New Zealand region, the South Atlantic, and both coasts of temperate South America.

Names of colors, where used originally, are chiefly those of Ridgway's 'Color Standards and Nomenclature' (1912). All measurements are in millimeters. In addition to the minimum and maximum, the average of each series of measurements is given in parentheses. Our measurement of depth of bill is taken just in front of the nasal eminences.

References under each species are chiefly to works quoted or cited in our text. For a complete bibliography, the monographs of Salvin (1896), Godman (1910), and Mathews (1912, 'Birds of Australia,' II) should be consulted.

PELECANOIDES LacépèdeSubgenus **PUFFINURIA** Lesson**Pelecanoides garnoti** (Lesson)

Plates XXI, Figure 1, XXII, Figure 1, XXIV, Figure 1

Puffinuria garnotii LESSON, 1828, 'Manuel d'Orn.' II, p. 394; 1828, 'Voy. Coquille,' Atlas, Pl. XLVI.

Pelecanoides garnoti COUES, 1866, Proc. Acad. Nat. Sci. Philadelphia, XVIII, p. 190.

SALVIN, 1896, 'Cat. Birds Brit. Mus.,' XXV, p. 439. GODMAN, 1910, 'Monogr. Petrels,' p. 307. Loomis, 1918, Proc. Calif. Acad. Sci., (4) II, No. 12, p. 67.

P [uffinuria] garnotii garnotii MATHEWS, 1912, 'Birds Australia,' II, p. 239.

P [uffinuria] garnotii lessoni MATHEWS, 1912, 'Birds Australia,' II, p. 239.

Halodroma garnoti COKER, 1908, Bull. U. S. Bur. Fisheries, XXVIII, pp. 361, 362.

TYPE SPECIMEN.—Not known, but well figured in 'Voy. Coquille,' Atlas, Pl. XLVI.

TYPE LOCALITY.—Coast of Peru, between San Gallan Island and Lima.¹

¹No definite locality is given in the description of the species by Lesson, who says, "*Le puffinure de Garnot habite par grandes troupes le long des cotes du Pérou.*" His colleague Garnot, however, in the course of his remarks on the anatomy of the species, states: "*Cet oiseau habite les parages entre San-gallan et Lima*" ('Voy. Coquille,' I, part 2, p. 611).

GEOGRAPHIC RANGE.—Western coast of South America, from Lobos de Tierra Island, Peru (lat. 6° 27' 45" S.), at least to Valparaiso, Chile.

GENERAL CHARACTERS.—Largest of the Pelecanoididæ; nearest to *P. magellani*, but much larger, especially in length of bill, wing, and tarsus. Gonyes more concave than in any other species. Natal down whitish.

ADULTS (SEXES ALIKE).—Upper surface black, each feather with a terminal band of glossy black, preceded by a grayish black area, which shades into the grayish white basal portion; the shafts mostly dark; scapulars mostly dusky neutral gray on outer web, grayish white on inner web, more or less concealed by the plumage of the interscapulum, but forming in many specimens an irregular, blotchy diagonal stripe; wings glossy black, more or less tinged with brownish, especially on primaries; secondaries narrowly tipped with whitish; inner webs of primaries clove-brown; under wing-coverts whitish, more or less washed with light mouse-gray, the shafts mostly dark; rectrices glossy black, fading to glossy brownish black, paler on the under surface; anterior part of forehead and lores suffused with clove-brown; under surface white; auriculars and malar region chestnut black; a fuscous area extending from the sides nearly to the middle of the breast, and sometimes extending entirely across as a faint mottling; axillaries dark mouse-gray to black; sides and flanks strongly washed with deep mouse-gray, the feathers sometimes narrowly tipped with whitish; feathers of tibia mouse-gray; down plumules and after-shafts over entire body deep mouse-gray. Paraseptal processes situated at the longitudinal center of the septum. Bill black; iris brown; tarsus and toes bluish; webs black.¹

Adult Male.—Length (skins), 217–238 (228.7); wing, 130–141 (136); tail, 33–43 (36.7); exposed culmen, 19–22 (20.4); width of bill, 8.5–10.5 (9.6); depth of bill, 7–9 (8.3); tarsus, 30–34 (32.9); middle toe and claw, 34–39 (36.9).²

Adult Female.—Length (skins), 209–239 (221.9); wing, 130.5–144 (136.6); tail, 33.5–41 (36.5); exposed culmen, 19–21 (19.7); width of bill, 8.5–10 (9.2); depth of bill, 7–8 (7.6); tarsus, 32–34 (32.5); middle toe and claw, 34.5–40 (36.3).³

NESTLING.—Natal down (protopyle) between pale gull-gray and white, attached to the tips of the mesoptyle down, which is mouse-gray in color but which fades appreciably before it is finally molted.

SPECIMENS EXAMINED.—Total number, 127, as follows:

Peru: Lobos de Tierra, 1⁴; Macabi Island, 1⁵; Ancon, 50^{4, 6}; Callao Bay, 5^{4, 6, 7, 8}; Chilca, 1⁶; Ballestas, North Island, 1⁸; San Gallan Island, 8^{6, 8}; Independence Bay, 1⁸

Chile: Coquimbo Bay, 2⁴; Valparaiso, 52^{4, 6, 8}; no specific locality, 1⁴

Locality unknown: 4^{4, 9, 10}

¹Colors of soft parts as stated on Beck's labels. In many cases, however, he gives the color of the iris as black or blackish.

²Twenty specimens.

³Twenty specimens.

⁴Collection Brit. Mus.

⁵Collection Mich. Univ. Mus.

⁶Brewster-Sanford Collection.

⁷Collection Acad. Nat. Sci. Phila.

⁸Collection U. S. Nat. Mus.

⁹Collection Boston Soc. Nat. Hist.

¹⁰Collection Zool. Mus., Tring.

NESTING SEASON.—Apparently throughout the year.

Egg.¹—Six collected at San Gallan Island, Peru, on July 4, 1913, range in form from short ovate to elongate ovate, one being extremely pointed at the smaller end; white, lusterless; measurements,² 48.5×33.6, 46×34.5, 46.7×34.2, 48×37, 47×34, 45×33 (average, 46.8×34.4). Average volume of the six, 24 cubic centimeters.

Mathews (*loc. cit.*, pp. 232, 233) has proposed to separate this form from the other species of *Pelecanoides* under the generic name *Puffinuria*. Our grounds for not according it this rank are given on pages 500-502.

Mathews (*loc. cit.*, p. 239) has also separated the bird of the coast of Chile from that of the coast of Peru, in the following words:

P [*uffinuria*] *garnotii lessoni*, subsp. n.; coast of Chili.

This form is much larger than the Peruvian bird, and has a noticeably heavier bill, with the inner wing-coverts gray and white-mottled.

Our examination of a very much larger series of specimens than was at Mathews' disposal has convinced us that the Chilean birds—from as far south, at least, as Valparaiso—are not entitled to subspecific recognition. The average measurements of Peruvian and Chilean specimens are presented in the following table:

TABLE I

	WING	TAIL	EXPOSED CULMEN	WIDTH OF BILL	DEPTH OF BILL	TARSUS	MIDDLE TOE AND CLAW
Ten Males from Peru ³	135.0	37.5	20.5	9.5	8.6	32.8	36.7
Ten Males from Chile ⁴	137.1	37.9	20.4	9.8	8.0	33.1	37.2
Ten Females from Peru ⁵	136.0	35.9	19.7	9.3	7.7	32.6	36.0
Ten Females from Chile ⁴	137.2	37.1	19.8	9.2	7.5	32.5	36.7

These differences in measurements are clearly too slight to warrant the separation of the Chilean birds as a distinct form. Furthermore, the coloration of the under wing-coverts seems too variable a character in the *Pelecanoididæ* to be of appreciable value in separating subspecies.

Still another subspecies proposed by Mathews (*P. g. magellani*) will be discussed under *Pelecanoides magellani*.

From Mr. Beck's notes on the labels of the Brewster-Sanford specimens, it appears that the species begins breeding on the coast of Peru in April.⁶ On May 8, 1913, he landed from a rowboat on one of the Pescadores Islets, eight miles off Ancon (thirty miles northwest of Lima)

¹The eggs described by Oates (1901, Cat. Birds' Eggs Brit. Mus., I, p. 161), under *P. garnoti*, clearly do not belong to this species.

²Cf. also Dr. Coker's measurements, p. 513.

³Ancon, 7; San Gallan Island, 2; Callao Bay, 1

⁴Valparaiso.

⁵Ancon, 8; San Gallan Island, 1; Chilca, 1.

⁶Dr. Coker's account (cf. pp. 511-513) makes it clear that the breeding season is prolonged throughout the year.

and found a single diving petrel nest, the chamber of which lay under a rock at the end of a tunnel through the soft but stony soil; it was lined with a number of cormorant feathers. On July 3, 1913, at San Gallan Island, off Pisco, he took three adults (two males and one female) on their nests and three nestlings varying in age from a few days to a number of weeks, the oldest of them having molted nearly all its mesoptyle down (Pl. XXI). On the following day, July 4, he collected six eggs, two of which were fresh-laid. In five out of the six instances a parent bird (Pl. XXIV) was incubating. The nest cavities, some of which were lined with a few diving petrel feathers, were either shallow hollows scratched out under rocks, or tunnels excavated to a depth of three or more feet. Some of them were dug into sandy flats, and some in the talus of hillsides. Beck likened the burrows to those of Cassin's auklets (*Ptychoramphus aleuticus*) of the Lower California islands. The principal colony of diving petrels, where the nests were very thickly distributed, was in a canyon about a mile from the water. Similar burrows were occupied by breeding Inca terns (*Larosterna inca*), and in a few cases the terns and diving petrels used a common entrance leading to their respective nest chambers.

The six eggs collected at San Gallan Island share with the eggs of almost all species of *Tubinares* a remarkable variation in shape. In volume, however, they are relatively uniform, ranging between 23 and 25.2 cubic centimeters, the average cubic contents of the six being 24 cc. They are therefore strikingly larger than eggs of *Pelecanoides georgicus* or *Pelecanoides urinatrix*. The average volume of two eggs of *Pelecanoides urinatrix berard*, for instance, is but 16.7 cc.; that of four eggs of *Pelecanoides georgicus*, 16.2 cc.

The following record is from Mr. Beck's field note-book.

Forty miles south of Salaverry, Peru, Jan. 5, 1913. Single diving petrels, and groups of as many as seven, seen from the steamer, ten or fifteen miles offshore. Their flight, when rising from the water, was similar to that of auklets. Some of the birds dived instead of rising.

Ten miles north of Callao, January 6. Numbers of divers seen, sometimes singly, never more than seven or eight together. In avoiding the steamer, they would sometimes dive and sometimes fly.

Off Ancon, Peru, April 24, 1913. Outside the islets, eight miles offshore, diving petrels were not uncommon. All were working southward, while under observation, from 12 o'clock noon until 3 P. M.

April 28. Only a half dozen diving petrels seen during a trip eight miles offshore and back again. One of the birds shot had molted its wing quills. It swam along under water a short distance with its wings spread. At first I thought it was a wounded bird.

May 1. Three or four diving petrels seen flying north. They passed my bait without paying any heed to it, although other petrels, such as *Thalassidroma tethys* and *Oceaniles gracilis*, came to the bait freely.

May 5. Numbers of diving petrels seen, mostly flying southward. Four or five were shot on the water and one of the wounded birds opened its wings and swam as murrelets do beneath the surface. Small sardine-like fish were abundant, and the stomachs of some of the divers were filled with them.

May 15. Twenty-nine diving petrels, mostly flying toward the south, were collected along with forty specimens of other petrels. The ocean was discolored with minute feed. Some of the divers were in the water, and now and then a number of them would burst out within a radius of a hundred yards. One of the specimens had lost all its flight feathers, the molt, therefore, being like that of an auklet or murre instead of in the usual petrel style in which the quills molt one or two at a time.

May 19. A half dozen diving petrels seen flying northward out of Callao Bay.

Six miles northwest of San Lorenzo Island, June 21. Many diving petrels on the water, singly, or in scattered groups of five or six.

Off Chilca, June 24. A single diver shot when it alighted near my bait.

June 28. A number of diving petrels seen sitting on the water just north of the Chincha Islands.

Arica, Chile, Aug. 25. Several diving petrels seen while we lay at anchor.

Iquique, Aug. 26. Diving petrels common just to the northward of the town.

Taltal [lat. 25° 30' S.], Aug. 28. Four or five seen flying near the steamer.

Valparaiso, Nov. 8. Scattering examples of diving petrels flying southward one to three miles offshore.

Nov. 11. A few divers; one shot. All the sea-birds are flying south at this season.

Nov. 19. Many divers working southward. They gave the boat a wide berth.

Nov. 24. Three or four seen.

Nov. 28. The last of the divers seen, still going south.

On October 22, 1913, Mr. Beck ran forty miles out to sea in a motor boat from Corral, the port of Valdivia, Chile (lat. 40° S.), but did not see a single diving petrel. Neither did he observe any on subsequent southward trips, so that the vicinity of Valparaiso is the southernmost point from which we have actual records of *Pelecanoides garnoti*. He saw none of these birds during his sojourn at the islands of the Juan Fernandez group, which lie about 450 miles off Valparaiso. In short, the geographical distribution and the breeding range appear to have the same limits, both being confined within the field of the cold Humboldt Current.

Mr. Beck's splendid series of 104 specimens, taken during the months of February to July and also in November, reveal many particulars of the life history.

This species, in common with numerous other tropical sea-birds, has a very protracted breeding season, or, rather, the date of deposition of the egg varies widely. Early in May, for instance, Mr. Beck dis-

covered nests, as recorded above; on July 3 he took several young birds, one of which was almost fully fledged, yet a day later he found fresh eggs. The subantarctic representatives of *Pelecanoides*, such as *magellani* and *georgicus*, have an apparently much more definite and limited season of egg-laying.

Certain seemingly vagarious features of the molt in *Pelecanoides garnoti* are doubtless also to be correlated with the life conditions of the tropical environment. A study of the majority of the skins in the Brewster-Sanford series indicates that normally a complete molt occurs between August and October, for most of the November specimens are in new plumage, while from this month forward the series as a whole shows progressive wear of the feathers up to and including the following winter season (July). Two specimens, referred to in Beck's notes of April 28 and May 15, were, however, molting at that time, and had lost at once most of the tail quills and all the remiges, both primary and secondary. Their condition is extraordinary for tubinarine birds, among which no doubt the phenomenon would be practicable only in this specialized, diving family to which the power of flight is not wholly essential. The state of the plumage in these two skins appears, moreover, to be out of harmony with conditions among nearly all of the other hundred specimens.

A few skins of non-breeding birds taken in July (the physiological status being indicated by Mr. Beck's careful notations regarding the sex organs) we believe to be yearlings that have not yet undergone the first molt of their teleoptyles.¹ The same condition is known to obtain in the genus *Oceanites*. Immature examples of *Pelecanoides garnoti* are apparently determinable even when they are more than a year old, for, while they have at this age acquired new wing quills, the rectricial molt is often found to have been incomplete, and one or more of the bleached, juvenal tail feathers, abraded as the plumes of only young petrels are wont to be, contrast strongly with their heavily pigmented successors. Such old rectrices are unquestionably more weathered and frayed than the corresponding year-old feathers of adult birds.

It is interesting to note that the first of the two neossoptyle plumages of *Pelecanoides garnoti* is whitish, whereas that of *P. georgicus* and *P. urinatrix* is dark gray. An analogy is to be found in the natal downs of two closely related penguins that have rather similar adult plumages, the chick of *Aptenodytes forsteri* being white, that of *A. patachonica*

¹The terms used in this paper for the plumage generations are those of Pycraft in Godman's 'Monograph of the Petrels.'

brown. The color of the neossoptyles in *Pelecanoides magellani* is unfortunately not known. The juvenal plumage of *Pelecanoides garnoti*, as shown by a fledgling taken from the nest, is indistinguishable from that of the adult. Even the complete, though faint, collar is visible on the jugulum of the young bird.

The following zoological and economic notes on this species were courteously placed at our disposal, after the remainder of our paper had gone to the editor, by Dr. R. E. Coker, of the United States Bureau of Fisheries. Dr. Coker has had long experience in the habitat of Garnot's diving petrel, and the account below is extracted from his manuscript on the habits and economic relations of the guano birds of Peru. These notes, with slight verbal alterations, have since been published.¹

Among the petrels, one is of particular interest and importance—the “*potoyunco*” (*Pelecanoides garnoti*)—a diving petrel, an abundant bird and a significant guano-producer. These petrels nest in considerable numbers in favored locations on the islands, and the guano formed in their subterranean chambers is considered particularly rich in nitrogenous matter. Only one egg is laid at a time, but the laying season extends throughout the year.

My first acquaintance with these birds was when at night in a small boat we often sailed close by them floating on the surface of the water and apparently quite unobservant of the boat. Not more than once have I seen them on the water by day—though the fishermen say that but one bird of the pair is at the nest during the day, the other remaining out on the ocean. On the islands, as far as my observations go, they are strictly nocturnal, coming and going only after dark and before the light of morning. They are more readily recognizable by sound than sight, and, as they fly obscurely about over the island, uttering their little croaks, they are very suggestive of bats.

The nests are made in the side of the hill, often just beneath a large rock or sheltered under the hard salty crust. It is an odd experience to sit at such a place and hear the mysterious sounds from subterranean homes. Over and over again, with the voice of a frog unvaried in pitch or rhythm, they repeat the sequence of notes—two longs, a short and a long, the last note slightly longer than the first two. Another more complicated sound is made by some, and it is possible that the calls are distinctive of the sexes.

The potoyunco is a comparatively small bird, measuring about ten inches in full length, from end of bill to tip of tail, and weighing half a pound. The general color is black above and white below. The body is thickly covered with feathers, beneath which is a thick gray down, the dense coat making the bird appear to possess a very large body. Viewed from below, the body is oval in form—like a large white egg—the wings and the short stout neck seeming disproportionately small appendages.

A number of the nests were observed at the Ballestas north island, and the birds were heard on the Chinchas; but the lofty San Gallan was the island *par excellence* for potoyuncos, as the potoyuncos were easily the principal bird of this large island.

¹1919, Proc. U. S. Nat. Mus., LVI, pp. 462-465.

San Gallan, 2.3 by 1.5 miles, is mostly dry, barren and dusty, but with high hills reaching well into the clouds, and, only there, in the moist altitudes, teeming with plant life. Everywhere over the island are large spots perforated by the holes of the potoyuncos as they undermine the hard dry crust of the lower hillsides, or burrow back underneath the vegetation of the cloud-wrapped peaks more than a thousand feet above sea-level.

Searching for these birds in the daytime one is guided only by the openings of the burrows, as their voice is rarely heard during the day. One may try quite a number of nests without result, as the burrow may either be unoccupied or, more often, too deep for the arm to reach to the nest. Still, so abundant are the nests on San Gallan,¹ that a considerable number of birds or eggs may be captured in an hour or two. Once reached, the birds are easily taken, as they make almost no effort at resistance. Sometimes after they are out, they try to bite, but without inflicting injury. Occasionally they will rush out into the hands held at the mouth of the gully.

At night, when one may be guided by the voices of the birds and avoid exploring the unoccupied homes, it is much easier to take them. It is thus that the laborers and fishermen catch them abundantly; for the potoyunco is valued for food in fresh or salted condition.

If liberated, they run rapidly over the ground, flapping the wings but unable to rise except after a run of ten or twenty feet. Then, with exceedingly rapid movement of their short wings, they make for the ocean with a queer zigzag flight. Reaching the ocean they fly low over the water a little distance, settle upon the surface, and then swim away, making short shallow dives.

When placed on the ground in my tent, the diving petrels displayed peculiar movements. The body is covered with a very thick coat of feathers so that, lying on the ground, the body seems to flatten out remarkably, while the wings, pushed a little out on the sides, increase the apparent width until the body has quite a turtle-like form. As they crawl rapidly along, the legs are spread well out to the sides and the body is barely if at all lifted from the ground. I noticed that with some the body was slightly raised, with others not at all. In any case the movement is a reptilian creep rather than a walk. When I started one under my sleeping bag it began to burrow with strong backward sweeps of the feet used alternately, and sent the dirt flying with great force. Two birds were placed outside in holes in the ground, each secured by a line attached to the leg. They made a little effort to burrow, but soon stopped. At 10 at night I found them trying to go toward the water. Placing them back in the holes, I left them again, hoping to ascertain the rate of excavation. Unfortunately, in the morning only the bones of the legs remained, and the tracks of gallinazos accounted for the disappearance of the birds.

Presumably both condors and gallinazos (buzzards) may be accounted enemies of the potoyuncos, although their subterranean life and nocturnal flights give them substantial protection from predatory birds. Certainly the chief enemy is man. About the signs of old camp-fires numberless wings of the potoyuncos were often observed. For a while I was puzzled by the many signs of sacks having been dragged

¹Since the present paper was set in type the senior author has visited San Gallan and other parts of the Peruvian coast. Accounts of his observations on the diving petrels have been published in the 'Brooklyn Museum Quarterly' as follows: Vol. VII, pp. 91, 93, 239-241, 242; Vol. VIII, pp. 97, 98, 102, 104, 105.

down the high hillsides, until it was observed that these trails led in almost every case to the grounds where there were burrows of potoyuncos—even to those near the very tops of the peaks. The ground was not torn up as if guano had been the object of search, and the abundant evidence of discarded wings of potoyuncos completed the story. The fishermen assured me that these birds were very good when salted, and that the laborers on the islands regularly brought back quantities of potoyuncos salted down. The fishermen with me asked permission to take the birds for food. This was refused, but without great effect, for I counted twenty-one birds drying in the sun one morning, and I know that they had first eaten all they had wanted.

A great many nests were examined, to find in each nest, if tenanted, only one egg or one young bird. The eggs are purest white, with very thin shell, and they are very variable in shape. Some are short and well rounded, with little difference between the ends, while others are very elongate and rather pointed at the smaller end. The measurements of six eggs of the potoyunco were as follows:

	1	2	3	4	5	6
Length	4.85	4.75	4.5	4.5	4.35	4.3 cm.
Width	3.1	3.6	3.4	3.3	3.3	3.4 cm.

A "pichon," or fledgling, at the stage when the wing feathers are first appearing, is a large shapeless mass of fat and down, with nearly the dimensions of its parents, and of equal weight. Its soft coating of gray down measures 3-4 cm. in thickness ($1\frac{1}{2}$ inches more or less). If a single tuft of down is pulled out there is found growing out of the blue sheath the delicate little feather which, for about 1 cm., is white (if from the lower side of the body) or black (if from the back); many of the barbs of the little feathers are with delicate plumes of down, which are dark gray for about 2 cm. and possess white tips of 1 cm. length. The head protruding from this great ball of down appears almost bald with only a close crop of gray down.

Valued as it is for food and readily open to capture, the potoyunco must eventually be brought near to extinction unless effective efforts for its protection are made. It will be unfortunate, indeed, if the potoyunco and the penguin, two water fowl which produce a fertilizer of high quality, shall, through mere human negligence or wastefulness, become lost to the guano industry. Valuable the potoyuncos may be as food, or the penguins for the skins or fat, and we may impose little personal blame on those who desire the food or the skins or the oils; but the fact remains that, when the food or the skin and oil is taken, the bird is lost to the future, while the removal of the guano is a benefit gained without loss. With due care each of these important species may not only be preserved to the future, but may be restored to a condition of far greater abundance and value than at the present time.

Subgenus **PORTHOMORNIS** Murphy and Harper

Pelecanoides magellani (Mathews)

Plates XX, XXI, Figure 2, XXII, Figure 1

Pelecanoides Berardi GOULD, 1841, 'Zool. Voy. H. M. S. Beagle,' part 3, 'Birds,' p. 138 (part).

Pelecanoides urinatrix SALVIN, 1896, 'Cat. Birds Brit. Mus.,' XXV, p. 437 (part). CRAWSHAY, 1907, 'Birds Tierra del Fuego,' p. 142. NICOLL, 1909, 'Three Voyages of a Naturalist,' pp. 160, 180; 1904, *Ibis*, pp. 41, 47. GODMAN, 1910, 'Monogr. Petrels,' p. 299 (part). TOWNSEND, 1910, *Pop. Sci. Monthly*, July, p. 6.

P [uffinuria] garnotii magellani MATHEWS, 1912, 'Birds Australia,' II, p. 239.

TYPE SPECIMEN.—Not designated in Mathews' description, which was probably based upon specimens in the British Museum.

TYPE LOCALITY.—Strait of Magellan.

GEOGRAPHIC RANGE.—Chilean, Fuegian, and Patagonian coastal and inland waterways, from Cape Horn north on the Pacific side of the continent to Trinidad Channel, and on the Atlantic side to Puerto Desêado, Province of Santa Cruz, Argentina.

GENERAL CHARACTERS.—Nearest to *garnoti* in general form of bill, to *urinatrix* in size. Differs from all other members of the family in the possession of white tips to feathers of back, upper rump, and wing-coverts (in fresh plumage), and in having a conspicuous falcate whitish area extending from the side of the neck to the occiput; the upper breast, moreover, is always pure white (never crossed by a mottled collar). Natal down not seen.

ADULTS (SEXES ALIKE).—Upper parts glossy black; feathers of the back and upper rump with narrow white tips, which disappear with wear (showing best in August specimens, entirely absent in some March specimens); scapulars dusky neutral gray (lighter on the inner web), with a terminal band of white (broader on the inner web); the scapulars forming a broken but distinct diagonal stripe of white; wing-coverts and secondaries glossy brownish black, the former with narrow, the latter with conspicuous, white tips and edges, which largely disappear with wear; primaries blackish brown, slightly glossed, becoming paler on the inner web; under wing-coverts white, a few feathers near the edge of the wing with dark shafts and splashed with blackish mouse-gray; rectrices black (fading to blackish brown), paler on the under surface, and several of the lateral feathers with narrow white tips, which disappear with wear; lores and anterior part of forehead suffused with clove-brown; under parts white, cheeks and sides of neck dark mouse-gray, the feathers with narrow white tips, except in worn plumage; a more or less distinct patch of white, falcate in shape, behind the cheeks, extending from the throat to the occiput; axillaries varying from dark to blackish mouse-gray; sides and flanks washed or broadly banded with dark neutral gray, the feathers with white tips, and the shafts black subterminally; feathers of tibia fuscous; down plumules and aftershafts over entire body deep neutral gray. Paraseptal processes situated posterior to the longitudinal center of the septum and not prominently developed. Bill blackish; iris brown; tarsus and toes bluish, webs black.¹

Adult Male.—Length (skins), 204–218 (209.8); wing, 120–133.5 (125.7); tail, 36–44 (40.5); exposed culmen, 15–17 (16); width of bill, 7.5–9 (8.1); depth of bill, 6–7 (6.4); tarsus, 26–30 (28.1); middle toe and claw, 31–36.5 (34).²

Adult Female.—Length (skins), 197–227 (208.5); wing, 121–132.5 (128); tail, 34–43.5 (39.3); exposed culmen, 15–17 (16.2); width of bill, 7–8.5 (7.9); depth of bill, 6–7 (6.2); tarsus, 27.5–29.5 (28.2); middle toe and claw, 31.5–36 (34.1).²

NESTLING.—Not seen.

SPECIMENS EXAMINED.—Total number, 87, as follows:

¹Color of soft parts from Beck's notations on labels. Nicoll writes: "Iris black; bill black; tarsus and toes blue-grey, with a black line down back of tarsus, webs black."

²Twenty specimens.

Chile and Argentina: Antonio Island, Trinidad Channel, 1¹; Molyneux Sound lat. 50° 17' S., long. 74° 54' W., 2¹; Caroline Island, 2²; London Island, 11²; Reydon Island, 1²; Hoste Island, 1²; False Cape Horn, 25²; Strait of Magellan, 19^{1 2}; Woods Bay [Strait of Magellan], 1¹; Punta Arenas, 18²; "Puerto Prat., Ultima Esperanza, Patagonia," 1¹; lat. 48° 27' S., long. 65° 36' W., 2.²

Locality unknown: 3.^{1 3 4}

NESTING SEASON.—November to March.

EGG.—Not seen.

Pelecanoides magellani, the diving petrel inhabiting the complex of Fuegian waterways, is a very well-marked and distinct species, probably the most distinctive and certainly the handsomest representative of the family. It is surprising that both Salvin⁵ and Godman⁶ should have synonymized it with *urinatrix*. Mathews considered it merely a subspecies of *garnoti*, and he described it in the following words.⁷

P [uffinuria] *garnotii magellani*, subsp. n. Straits of Magellan.

This bird is easily referable to the genus *Puffinuria* by its bill characters, and is separable from the preceding [*P. g. lessoni*] by its inferior size and the pure white coloration of the inner wing.

The differences in proportions and bill structure between this bird and *P. garnoti* are altogether too marked to admit of their being considered races of the same species, as we have pointed out in our synopsis of the subgenera. Furthermore, the invariable whiteness of the throat, and the white tips on feathers of the upper parts, are unique, qualitative characters (Plates XX-XXII).

A skin in the British Museum (No. 81.5.1.6075) is evidently the one which Salvin listed as specimen "r" under *Pelecanoides urinatrix* in the Catalogue of Birds, XXV, p. 438, with the comment, "Type of *Haladroma tenuirostris* Eyton." One of the labels on the specimen itself bears the following data: "*Haladroma tenuirostris* Eyton. Original." This name appears nowhere else in the literature, so far as we have discovered, and is, accordingly a *nomen nudum*. Though neither locality nor date appear upon the labels, the specimen must have come from the Magellan region, since it is a *Pelecanoides magellani* beyond a doubt. It is evidently an immature bird, with a weak bill and measurements generally below the average.

The best published observations on *Pelecanoides magellani* in nature are those of Charles Darwin (cf. Gould, *loc. cit.*), who supplied Gould

¹Collection Brit. Mus.

²Brewster-Sanford Collection.

³Collection Mus. Comp. Zool.

⁴Collection Zool. Mus., Tring.

⁵Cat. Birds Brit. Mus., XXV, p. 437

⁶Monogr. Petrels, p. 299.

⁷Birds Australia, II, p. 239.

with the account quoted below. In referring, however, to its occurrence "as far north as the Chonos Archipelago," he was unaware of the existence of another diving petrel (*Pelecanoides urinatrix coppingeri*), which probably inhabits this part of the coast. Darwin wrote as follows:

This bird is common in the deep and quiet creeks and inland seas of Tierra del Fuego, and on the west coast of Patagonia, as far north as the Chonos Archipelago. I never saw but one in the open sea, and that was between Tierra del Fuego and the Falkland Islands. This bird is a complete auk in its habits, although from its structure it must be classed with the Petrels. To the latter Mr. Gould informs me, its affinity is clearly shewn by the form of its beak and nostrils, length of foot, and even by the general colouring of its plumage. To the auks it is related in the general form of its body, its short wings, shape of tail, and absence of hind-toe to the foot. When seen from a distance and undisturbed, it would almost certainly be mistaken, from its manner of swimming and frequent diving, for a grebe. When approached in a boat, it generally dives to a distance, and on coming to the surface, with the same movement takes flight: having flown some way, it drops like a stone on the water, as if struck dead, and instantaneously dives again. No one seeing this bird for the first time, thus diving like a grebe and flying in a straight line by the rapid movement of its short wings like an auk, would be willing to believe that it was a member of the family of petrels. . . . I observed at Port Famine, that these birds, in the evening, sometimes flew in straight lines from one part of the sound to another; but during the day, they scarcely ever, I believe, take wing, if undisturbed. They are not very wild: if they had been so, from their habit of diving and flying, it would have been extremely difficult to have procured a specimen. The legs of this bird are "flax-flower blue."

The general likeness of the diving petrels and the auklets has been mentioned in the literature many times since Darwin wrote the paragraph just quoted, but it has not hitherto been pointed out that the plumage of this species, *Pelecanoides magellani*, now for the first time fully recognized, so strikingly resembles the winter plumage of the dovekie (*Alle alle*). The remarkable similarity between these two unrelated birds involves not only size, the approximate proportions of the limbs and tail, and absence of the hind toe, but also the color and texture of the whole dorsal and ventral surfaces, the common possession of a falcate white area at the sides of the neck, and the presence of white markings on the proximal flight feathers and their coverts. Indeed, the homoplastic resemblance of the Fuegian diving petrel and the dovekie, illustrated in Plate XX, constitutes one of the best examples of convergent evolution known among vertebrates.

As regards the pygopode-like character of the feathers of diving petrels, Coues has written as follows:

In the wings and tail the urinatorial aspect is most decidedly marked. The very short wings, with their stiff, falcate, subacuminate primaries hardly reach to the end of the exceedingly abbreviated tail.

The plumage is essentially diverse from that of any other Procellariid, in its compact imbrication, and oily glossiness, which comes nearest to that of the Loons; and is eminently adapted to resist the action of the water in which the habits of this species cause them so constantly to be submerged.

The analogy existing between the diving petrels and the auklets will be referred to again in the discussion of *Pelecanoides georgicus* (pp. 530-533).

Nicoll has given the following account of the present species.

I first saw these curious little Petrels the day before we reached the Straits of Magellan. I watched them all the afternoon rising under our bows, flying for a short distance with a feeble fluttering flight, and then diving again suddenly into the water. They were abundant all through the Straits and Smythe's Channel, but were not easy to shoot, as they dived at the flash of the gun.¹

In Molineux Sound two examples of the diving petrel were obtained. . . . When skinning this bird, one cannot fail to be struck by the curious formation of the gizzard, which is soft and flabby, and is, in fact, merely an enlargement of the proventriculus. All those I examined were crammed with small fishes.²

Mr. Beck saw a great deal of this diving petrel during his several wanderings in the intricate Magellanic waterways, where he collected seventy-eight specimens. He did not succeed in finding an egg or nestling, although on Hermite Island, just northwest of Cape Horn, a dog scratched at a crevice under a large boulder, and Mr. Beck believed that a diver was nesting within. A native sealer told him that he had once found a nest of this bird on one of the islands to the westward of Cockburn Channel. It was several hundred feet above sea-level, and was unearthed by his dog while they were searching for sea-otter holes on a rocky hillside.

Mr. Beck's notes do not confirm Nicoll's observations that the straits-living diving petrel flies in a less sustained and less vigorous manner than the pelagic species of Tristan da Cunha.³ At the western end of Cockburn Channel, in the vicinity of Cape Horn, and off the east coast of Patagonia, Beck often saw *Pelecanoides magellani* flying straightaway for long distances—quite out of sight, in fact. He reports that when the birds flew low they sometimes struck the crests of choppy waves, being checked for a moment in their course and then recovering. His notes further state that this species does not feed in flocks like the whalebirds (*Pachyptila*) but, rather, individually or in very small, scattered groups. They appeared to feed particularly in "streaks" on the water caused doubtless by the effluvia of their prey. Beck occasionally saw single birds pop into flight from beneath the surface. The stomachs of some that he shot were distended with invertebrates.

¹1904, *Ibis*, p. 47.

²1900, 'Three Voyages of a Naturalist,' 2d Ed., p. 180.

³Cf. p. 542.

The following notes are extracted from Mr. Beck's journal.

Punta Arenas, July 8 and 9, 1914. Diving petrels scattering; about thirty collected in the strait north of the town.

Nov. 17. Coming by steamer from the Atlantic into the Strait of Magellan; a few diving petrels off Cape Virgenes. Within the strait they were much less common than they had been three months before.

London Island, at the western end of Beagle Channel, Nov. 30. Diving petrels came into the protected bay for shelter from a williwaw; several shot.

Caroline Island, Dec. 7-14. Two diving petrels collected.

Lort Bay, False Cape Horn (Hoste Island), Dec. 26. Out in boat for two hours, and shot twenty diving petrels, which were common. Many came into the bay from the northward to feed.

Between Hermite and Wollaston islands, Dec. 28. One diver seen.

London Island, Jan. 18, 1915. Rain and squalls all day, but diving petrels did not come into the bay as they usually do in such weather. Only one seen and collected.

Junction of Beagle Channel and Magellan Strait, western Tierra del Fuego, Jan. 21. A few diving petrels seen.

Twenty miles north of Punta Arenas, March 6. Fifteen or twenty shot.

Lort Bay, April 7, 8, and 9. Where dozens of diving petrels had been seen in December, only one was noted during these three April days.

Lort Bay, April 20. Two seen.

At sea, 80 miles east of San Sebastian Bay, Argentina (east coast of Tierra del Fuego). High southwest winds. Three diving petrels seen.

Off Rio Gallegos, Patagonia (60 miles north of the eastern entrance of the Strait of Magellan), May 11. Strong south wind. Diving petrels were common five to ten miles offshore in the heavy sea.

Between Rio Gallegos and Rio Santa Cruz, May 24. Many diving petrels among other fishing birds, 20 miles offshore.

Four miles off Cape Virgenes, May 26. Two diving petrels noted.

Strait of Magellan, east of Punta Arenas, June 11. A few diving petrels seen.

Ushuaia, Beagle Channel, July 15 (mid-winter). One or two seen.

False Cape Horn, July 25. Two seen.

Off the mouth of the Rio Gallegos, Argentina, Aug. 8. A strong offshore wind, and a swift tide, during the forenoon. Several diving petrels were noted, keeping within two or three miles of the land.

At sea, 50 miles northeast of Rio Gallegos, Sept. 10. Three or four diving petrels seen.

At sea, 40 miles east of Puerto Deseado, Sept. 13. Two seen.

At sea, lat. 48° 27' S., 65° 36' W., Sept. 15. Several diving petrels collected.

Punta Delgada, Strait of Magellan, Oct. 4. Many diving petrels flying within the Strait.

The Brewster-Sanford series of *Pelecanoides magellani* comprises specimens collected during the months of January, March, July, August, September, November, and December. Adults shot in November and December had enlarged gonads and bare brood-patches; a female taken at London Island on November 30 contained an "egg ready to lay within

two days." By March some of the young birds leave the nest. A female fledgling (Brewster-Sanford Coll., 2855) collected at Punta Arenas on March 6, 1915, shows the diagnostic characters of the species, i.e., the very black dorsal surface, pure white throat, falcate area behind the cheeks, and broad white edgings on the proximal wing feathers. It lacks, however, the beautiful white terminations of the dorsal body feathers, which markings are therefore proved to be indicative of maturity. The fledglings have, moreover, weak bills and small claws, such as are characteristic of juvenal *Tubinares* in general.

The annual molt of the Fuegian diving petrel occurs between the first of April and the end of June, for specimens taken in July are in very bright plumage, with new remiges and rectrices and with the delicate, white, lunulate, terminal markings distributed all over the interscapular region and upper rump. From July onward the abrasion of the plumage is so uniform that the authors find it easy to guess, with approximate correctness, the dates of capture of individual specimens merely by noting the condition of their plumage. March birds are relatively worn and dingy, and in nearly all instances the white edgings on the back have entirely disappeared. The progress of wear and fading throughout the year is illustrated by three typical examples in figure 2 of plate XXI.

The series of skins at our disposal presents considerable evidence that the young do not molt their contour feathers during the first season. December specimens of *Pelecanoides magellani*, for instance, are of two kinds, viz., birds with moderately worn plumage, which are evidently adults, and others, with feathers very much worn and frayed, which we believe to be the young of the preceding breeding season. Some of the latter specimens have particularly ragged quills, and they all lack the white interscapular markings. The plumage sequences of this species are therefore assumed to be virtually the same as those of *Oceanites oceanicus*, which have been worked out in some detail by Murphy.¹

Subgenus **PELAGODYPTES** Murphy and Harper

Pelecanoides georgicus Murphy and Harper

Plates XXII, Figures 1 and 2, XXIII, Figures 1 and 2.

Pelecanoides urinatrix variety *Berardi* VON DEN STEINEN, 1890, 'Die Deutschen Exp. und ihre Erg.', II, p. 240.

Pelecanoides urinatrix LÖNNBERG, 1906, Kungl. Sv. Vet. Akademiens Handlingar, XL, No. 5, p. 73. GODMAN, 1910, 'Monogr. Petrels,' p. 299 (part). MURPHY, 1914, Auk, XXXI, pp. 450, 456.

¹1918, Bull. Amer. Mus. Nat. Hist., XXXVIII, pp. 118-122.

Pelecanoides exsul LÖNNBERG, *op. cit.*, p. 74.

Pelecanoides georgica MURPHY and HARPER, 1916, Bull. Amer. Mus. Nat. Hist., XXXV, p. 66.

TYPE SPECIMEN.—No. 132451, American Museum of Natural History; adult male; collected December 26, 1914, by Joseph G. Correia.

TYPE LOCALITY.—Cumberland Bay, South Georgia, latitude 54° 16' S., longitude 36° 26' W.

GEOGRAPHIC RANGE.—South Georgia, Macquarie Island, and waters adjacent to each.

GENERAL CHARACTERS.—Size small, approximating that of *P. urinatrix chathamensis*; bill proportionately wider at the base, and tapering more sharply, than in other Pelecanoididae; mottling of jugulum decidedly variable, becoming very pronounced in some specimens. Natal down gray.

ADULTS (SEXES ALIKE).—Upper parts glossy black; scapulars grayish white, with an obscure subterminal band of deep neutral gray, broader and slightly darker on outer web; the scapulars more or less overlaid and concealed by the dark interscapulars, but forming in many specimens a broad, conspicuous diagonal stripe; wings glossy black, more or less tinged with brownish, especially on primaries; secondaries generally edged narrowly with whitish, and primaries becoming pale on edge of inner web; under wing-coverts white, sometimes mottled with pale neutral gray, and the shafts sometimes dark terminally; rectrices blackish brown, with a slight gloss, paler on the under surface, and the worn lateral feathers sometimes showing whitish edges; anterior part of forehead and lores suffused with clove-brown; under parts white; cheeks and sides of neck deep neutral gray, the feathers narrowly tipped with white; this gray mottling varying much in intensity and distribution, and in some specimens extending completely across the jugulum; axillaries, sides, and flanks barred more or less strongly with neutral gray, the feathers tipped with white; feathers of tibia deep mouse-gray; down plumules and aftershafts over entire body varying from deep mouse-gray to dark mouse-gray, with lighter tips. Paraseptal processes situated at the longitudinal center of the septum. Bill black, rami of mandible slaty; iris seal-brown; tarsi and toes flax-flower blue; webs black.¹

Adult Male.—Length (skins), 193–218 (202.6); wing, 104–122 (112.7); tail, 34–42 (37.7); exposed culmen, 14–16 (14.9); width of bill, 8–10 (8.9); depth of bill, 5.5–6 (5.8); tarsus, 22–26 (24.4); middle toe and claw, 27–33 (30.1).²

Adult Female.—Length (skins), 181–215 (198.2); wing, 104–120 (113.8); tail, 34–43 (38.2); exposed culmen, 14–16 (14.7); width of bill, 8–9.5 (8.8); depth of bill, 5–6 (5.7); tarsus, 21–26 (24.2); middle toe and claw, 26–32 (29.9).³

NESTLING.—Protoptyle down light mouse-gray on the upper surface of the body, pallid mouse-gray beneath, where it is also much shorter than above; throat and sides of head nearly bare. Mesoptyle down drab-gray; longer, less dense, and of looser texture above than on the ventral surface. Contour feathers appearing first on the bare parts of head and throat, then on wings, tail, and back. Down lost progressively from head, wings, back, flanks, and breast, clinging longest on the belly, and fading decidedly with age (Fig. 4).

¹Colors of soft parts as noted in living specimen.

²One hundred specimens; only twenty, however, measured for total length and for depth of bill.

³Eighty-five specimens; only twenty, however, measured for total length and for depth of bill.

SPECIMENS EXAMINED.—Total number, 250, as follows:

South Georgia, 247¹; 2-3; Macquarie Island, 2³; "Island south of New Zealand,"

NESTING SEASON.—November to March.

EGG.—Ovate, short ovate, or oval; pure white, lusterless; measurements of our specimens, 38.5×32, 39×30, 39×31, 41×32.3 (average, 39.4×31.3). A "runt" egg is subspherical and measures 24.5×22. Average volume of the four normal eggs, 6.2 cubic centimeters.

Observations on *Pelecanoides georgicus* were made by the senior writer in 1912–1913 during the South Georgia Expedition of the Brooklyn Museum and The American Museum of Natural History. A large series of beautifully prepared specimens of diving petrels was subsequently collected at South Georgia by Mr. Joseph G. Correia, of New Bedford, Mass. The following data on the life history of the species are taken chiefly from Mr. Murphy's notebook, but in part from information supplied by Mr. Correia.

Divers were first observed at sea in latitude 50° 12' S., longitude 44° 47' W., on November 20, 1912. This is about 280 miles north of South Georgia. None were noted again until February 24, 1913, when many were seen at dusk in the main channel of the Bay of Isles, South Georgia. On February 27 a breeding colony was discovered in a broad valley which runs eastward from the head of Possession Bay between two high, symmetrical mountain peaks. The floor of the valley is partly of broken stone, partly grassy, with some water-saturated moss and several glacier streams. *Pelecanoides* burrows were distributed from the shore of the bay to the higher slopes two miles inland, not only on banks and knolls, but also on the flat itself, wherever a little bed of clay and sand covered with vegetation was raised a foot or so above the general tony level. The excavations were hardly larger than field-mouse holes, at least at the entrance (7 cm. in diameter, according to von den Steinen); but some of them were as much as six feet in length. As a general rule, they led down steeply for a few inches and then ran horizontally but with sharp lateral turns. Some tunnels were doubled back almost on their own tracks, and often there was a diverticulum just outside of the nest chamber. Here and there a burrow ran beneath a roof of the tangled roots of a rosaceous herb (*Acæna adscendens*). It frequently happened that the course was changed by stones encountered during the digging, and that the nest chamber lay under a stone. The chambers were unlined except for a little down and an occasional bit of lichen, perhaps

¹Collection Brooklyn Mus., now in part distributed.

²Collection Amer. Mus. Nat. Hist.

³Collection Zool. Mus., Tring.

introduced by accident. Most of the nests contained well-grown young, a few of which had all but lost the down. Each of two nests dug open on March 3 held one adult bird, but neither egg nor young.

All the young divers found were exceedingly fat, except for one or two poor starvelings which were reduced to a condition of mere feathers and bones, and which had crawled to the mouths of their burrows in vain expectation of their parents, when no doubt the latter had been accounted for by some skua (*Catharacta*) days or perhaps weeks before. Other nests contained emaciated dead young, and told of the consummation of similar tragedies.

During a snowstorm on the evening of March 13, two diving petrels (Pl. XXIII), dazzled by a lantern, flew on board our vessel which lay at anchor in Possession Bay. The captain of a Norwegian "floating whaling-factory" informed us that when he had moored his steamer in Possession Bay one January night, the decks had suddenly swarmed with divers attracted by the lights.

On March 15, 1913, our vessel stood to sea from Possession Bay, when the senior writer fortunately had occasion to make a trip in a row-boat to a neighboring whaling station for the purpose of posting mail. Shortly after sunset we started on a ten-mile pull to the brig offshore, and as soon as we were well beyond the mouth of the bay our boat was continually in the midst of innumerable small *Tubinares* flocking over the calm dusky sea. *Oceanites*, *Fregetta grallaria*, *Petrella capensis*, and diving petrels made up the bulk of these birds, which fluttered all about us like bats. Diving petrels also covered the water in swimming flocks, and often took to flight at the approach of the boat, usually diving again within a short distance. In spite of the diminutive size of their wings, they seemed to fly at very high speed.

Divers were observed on the bays of South Georgia throughout the year by members of the German 'Transit of Venus' Expedition. Doubtless most of them spend the months of the southern winter on the neighboring or distant seas, returning to the breeding grounds in October. The excavation of their long burrows through hard, stony, often frozen soil is a tremendous task, accomplished entirely at night by the employment of both the bill and the strongly clawed feet. Before dawn the birds discontinue their labor and retreat to sea, so avoiding their ever-present enemy, the skua. That numbers of them are nevertheless captured is indicated by dismembered skeletons on the ground in the neighborhood of the colonies.

When the burrows have been completed, the mated pair can usually be found together, until the egg is laid, after which only one bird remains in the nest chamber at a time. After hatching, the young bird is invariably left quite alone between daybreak and dark. Not infrequently the diver colonies are temporarily obliterated by a heavy covering of snow.

The advent of man at South Georgia has brought a more insidious enemy of the divers than the skua, for in the subterranean runways of introduced rats have been found great quantities of cleanly picked *Pelecanoides* bones.

No food substances were found within the stomachs of South Georgian diving petrels, but only occasional pebbles. A stomach preserved in alcohol contains four fragments of clay-slate, the largest of which measures 10×6 mm.

All of the 247 specimens of South Georgian diving petrels examined by the writers (except possibly one, an undated specimen of von den Steinen's) were taken between the dates November 29 and March 13, or within the limits of the breeding season. The series, therefore, throws no light upon the molt, which, in this most austral species of the family, is doubtless postnuptial and very regular.

Growth and molt of the downy plumages of young birds are illustrated in figure 4. The smallest specimen (110 mm. in total length) is clothed with short, straight protoptyles, varying in color from pallid mouse-gray beneath to a slightly darker gray above. The dorsal down is much longer; the throat and the sides of the head are practically bare. The next specimen is evidently considerably older (185 mm. in length), and is clad in long, dense, rather curly mesoptyle down, drab-gray in color and of looser texture above than below. The contour plumage is appearing in the form of pin-feathers on the bare throat and cheeks, and the primaries have sprouted to a length approaching 30 mm., although the rectrices have scarcely punctured the skin. Fig. 4 sufficiently indicates the further progress of growth, but it is interesting to note that the last tufts of much bleached mesoptyles cling to the center of the belly, where they serve as a cushion or mattress until the nestling has attained practically its full development.

One of our fledglings, taken from the burrow, had lost the last trace of its down as early as March 15. The juvenal plumage is indistinguishable from that of breeding birds, except that no mottled areas on the jugulum are to be seen among our series of fledglings, and the brownish tinge on forehead and lores is usually fainter and less extensive than in



Fig. 4. Growth and molt of the neomorphs in nestlings of *Pelecanoides georgicus*. The seven specimens, all in the collection of the Brooklyn Museum, were taken at various colonies in South Georgia between the dates February 8 and March 15.

adults. Young birds taken after they have left the nesting grounds are at once determinable, however, because of their weak and slender bills. A knowledge of this has enabled us to understand by analogy the status of immature diving petrels of other species collected at sea in the New Zealand region and elsewhere.

This species was considered by the writers to be confined entirely to South Georgia and vicinity, until the present paper was already in proof. It was then discovered that two specimens in the Tring Museum, collected at Macquarie Island, were almost, if not quite, identical with South Georgia specimens. In the shape of the bill and the nasal orifices, in the position of the paraseptal processes at approximately the longitudinal center of the septum, and in practically every detail of plumage, they exhibit such exceedingly close affinities with *P. georgicus* that we feel unable to separate them even subspecifically. The measurements of the two specimens, an adult male and female, collected in October 1899 and received from H. Travers, are, respectively, as follows: length (skins), 186, 182; wing, 107.5, 109.5; tail, 39, 35; exposed culmen, 14.5, 14.5; width of bill, 8.8; depth of bill, 6.6; tarsus, 22, 23; middle toe and claw, 27.5, 28. The same museum contains a third specimen, an adult male, which, according to the data on the label, was found in the London market in frozen condition on March 2, 1905, and came from an "Is. S. of New Zealand." This island, in all likelihood, was Macquarie, for the specimen agrees entirely with the two mentioned above and is quite unlike any others which we have examined from the whole New Zealand region. Its measurements are: length (skin), 176; wing, 110.5; tail, 36; exposed culmen, 14.5; width of bill, 7.5; depth of bill, 6; tarsus, 23.5; middle toe and claw, 28.5. Most of the measurements of these three specimens are slightly below the average, but above the minima, for the large series from South Georgia. The mottling at the sides of the neck does not extend across the jugulum in any of these three, as it does in some of the South Georgia specimens.

The discovery of these representatives of *P. georgicus* from Macquarie Island is of exceptional interest from several points of view. In the first place, South Georgia and Macquarie Island are situated on almost exactly opposite sides of the South Pole, and are over 8000 miles distant from each other across the South Atlantic and Indian oceans along the parallel of latitude. Though both are situated at the same latitude, South Georgia lies within and Macquarie Island without the extreme limit of pack-ice. Apparently, then, the exact limit of the pack-ice is not a significant factor in the distribution of the species. The

occurrence of *P. georgicus* at two such widely separated localities is perhaps somewhat comparable with the distribution of *Bulweria bulweri*, *Oceanodroma castro*, and *Oceanodroma leucorhoa*, although there is no continental barrier between the extremes of its range, as there is between the Atlantic and Pacific ranges of the other three species just mentioned. Indeed, we may now look with some confidence for the discovery of *P. georgicus*, or some closely allied representative of the subgenus *Pelagodiptes*, at other subantarctic islands lying between the 53d and 60th parallels of south latitude, such as the South Sandwich group, Lindsay (or Bouvet) Island, McDonald and Heard Islands, Emerald Island, and the islets of Nimrod and Dougherty (if they really exist).

Several diving petrels were observed by the 'Scotia' expedition in latitude 52° 31' S. to 51° S., longitude approximately 9° W. From climatic considerations it appears likely that these were *P. georgicus* rather than *P. u. dacunhæ*.

The peculiar value of our large series of South Georgian diving petrels, not only to this review but to a comprehension of the biology of Tubinares in general, lies in the fact that an intensive study of these specimens, which comprise birds of so many different ages and physiological conditions, may help in solving problems among other species represented only by fragmentary material. With this in mind, it will be of interest to consider the question of variation within so well-defined a species as this isolated, insular form.

Color

Dichromatism is a familiar phenomenon among Tubinares, but color variation in *Pelecanoides georgicus* seems to be confined wholly to the extent of gray mottling at the sides of the white throat, across the jugulum, and along the flanks. The extremes of variation among the specimens that we have examined are illustrated in figure 2 of plate XXIII. It was this difference that led Lönnberg to record his South Georgia specimens as representing both "*Pelecanoides urinatrix*" and "*Pelecanoides exsul*." As a matter of fact, the mottling of *georgicus* does not approach that of *P. exsul* in either distinctness or extent. It seems, however, to vary in approximately the same degree as within the subspecies *P. u. urinatrix*. On the other hand, the variation of mottling from individual to individual is of much wider amplitude than in *P. canoides garnoti*, in which species the faint, fuscous mottling is remarkably uniform; in *Pelecanoides magellani* there is never a trace of a jugular collar. We can determine no correlation

color variation of *Pelecanoides georgicus* and sex, age, season of capture, or condition of plumage. As regards coloration and size, we can only say, with reserve, that more of the mottled birds are above the average in dimensions than below.

Form and Dimensions

There has been a tendency, beginning as far back as the date of Coues' monograph and recently emphasized by Loomis (*op. cit.*), to attribute an extraordinary amount of individual variation of structure and dimensions to tubinarine species. Since our large collection of adult, breeding specimens of *Pelecanoides georgicus*, numbering nearly two hundred skins, offers an exceptional opportunity for the investigation of individual variation as distinct from variation of other kinds, we have made detailed measurements of the entire series, and these are summarized in Tables II to IV.

Table II lists in chronological order the average measurements of groups of breeding petrels captured within their burrows during three months of the nesting season. The data for 100 males and 85 females are listed separately, the number of specimens included for each date being indicated in the third vertical column. The object in tabulating these figures was to determine whether there existed a sequence in size which might be correlated with age, that is, whether the younger birds (i.e., those with smaller proportions, especially of bill), breeding for the first time, showed a tendency to reproduce earlier or later in the breeding season than their elders. The senior writer has observed such seasonal differences, obviously associated with difference in age, in the large albatross, *Diomedea exulans*. But, as the table demonstrates, no such conclusion can be drawn in the case of *Pelecanoides georgicus*. The evidence for individual variability of breeding birds is entirely negative.

In Table IV it will be seen that the average measurements of 100 males and 85 females are as to be virtually the same, although the maximum dimensions are somewhat greater among males and most of the measurements are greater among males. The ranges of variation for each dimension are also given, as represented by percentages of the mean dimensions. The measurements are generally in good agreement with the same data for *Oceanodroma* (Table V). Except in

the case of the length of toe and claw, the noteworthy discrepancies are indeed accounted for by the fact that the *Oceanites* measurements are based upon both immature and adult specimens taken at many seasons of the year and over a wide area, whereas the *Pelecanoides* figures are derived from breeding adults in an approximately uniform state of plumage. The two tables are, in fact, comparable only when it is borne in mind that the *Pelecanoides* percentages represent true individual variation, while the *Oceanites* percentages represent individual plus age, seasonal or physiological, and possibly geographic, variation. Age and the relation of a bird's plumage at any one time to its plumage after the season of periodical renewal have an important bearing, which is too often overlooked, upon measurements that may be used as the basis of taxonomic characterization.

TABLE II

SEX	DATE	NUMBER OF SPECIMENS	WING	TAIL	EXPOSED CULMEN	WIDTH OF BILL AT BASE	TARSUS	MIDDLE TOE AND CLAW
			mm.	mm.	mm.	mm.	mm.	mm.
Males	Nov. 29	3	115.7	40.0	14.8	9.0	24.0	29.3
	Dec. 6	9	112.9	38.2	15.1	8.8	24.7	30.1
	Dec. 13	16	112.2	38.4	14.9	8.9	24.5	30.1
	Dec. 20	20	112.8	37.8	14.9	8.9	24.4	29.8
	Dec. 26	17	112.0	36.9	14.8	8.8	24.4	30.4
	Jan. 1	7	114.3	38.1	15.0	9.0	24.4	30.1
	Jan. 10 and 11	12	113.2	37.3	14.8	8.9	24.3	29.8
	Jan. 17	11	112.2	37.3	15.2	9.0	24.3	30.6
	Jan. 31	2	114.0	37.5	16.0	8.8	24.0	29.0
	Feb. 8, 22, and 28	3	108.7	35.3	15.2	8.8	23.3	30.3
	Total	100						
Females	Nov. 29	5	112.6	38.8	14.6	9.0	24.6	30.6
	Dec. 6	12	113.4	38.8	14.8	8.8	24.0	29.7
	Dec. 13	6	112.7	38.7	14.8	8.9	24.6	30.6
	Dec. 20	8	114.3	38.4	15.0	8.5	24.0	29.5
	Dec. 26 and 30	18	114.2	37.9	14.7	8.6	24.1	29.9
	Jan. 1	13	114.5	38.9	14.7	9.0	24.0	29.3
	Jan. 10	10	114.0	37.1	15.0	8.9	24.5	30.1
	Jan. 17	8	114.5	38.4	14.7	8.9	24.6	30.0
	Jan. 31	2	110.5	35.0	15.0	8.8	23.8	30.0
	Feb. 2 and 8	3	111.7	36.0	14.5	8.0	23.7	30.3
	Total	85						

TABLE III

	WING	TAIL	EXPOSED CULMEN	WIDTH OF BILL AT BASE	TARSUS	MIDDLE TOE AND CLAW
	<i>mm.</i>	<i>mm.</i>	<i>mm.</i>	<i>mm.</i>	<i>mm.</i>	<i>mm.</i>
Average Measurements of 100 Breeding Males	112.7	37.7	14.9	8.9	24.4	30.1
Minimum Measurement for Each Dimension	104.0	34.0	14.0	8.0	22.0	27.0
Maximum Measurement for Each Dimension	122.0	42.0	16.0	10.0	26.0	33.0
Mid-point of Amplitude of Variation	113.0	38.0	15.0	9.0	24.0	30.0
Variation on Either Side of Mid-point	9.0	4.0	1.0	1.0	2.0	3.0
Percentage of the Average to Which the Amplitude of Variation Amounts	16.0	21.0	13.4	22.5	16.4	20.0
Percentage of Specimens Attain- ing the Minimum for Each Dimension	1.0	4.0	17.0	4.0	1.0	1.0
Percentage of Specimens Attain- ing the Maximum for Each Dimension	1.0	1.0	16.0	1.0	5.0	1.0
Percentage of Specimens Varying Below the Average	42.0	43.0	34.0	28.0	55.0	68.0
Percentage of Specimens Varying Above the Average	58.0	57.0	66.0	72.0	43.0	32.0

TABLE IV

	WING	TAIL	EXPOSED CULMEN	WIDTH OF BILL AT BASE	TARSUS	MIDDLE TOE AND CLAW
	<i>mm.</i>	<i>mm.</i>	<i>mm.</i>	<i>mm.</i>	<i>mm.</i>	<i>mm.</i>
Average Measurements of 85 Breeding Females	113.8	38.2	14.7	8.8	24.2	29.9
Minimum Measurement for Each Dimension	104.0	34.0	14.0	8.0	21.0	26.0
Maximum Measurement for Each Dimension	120.0	43.0	16.0	9.5	26.0	32.0
Mid-point of Amplitude of Variation	112.0	38.5	15.0	8.8	23.5	29.0
Variation on Either Side of Mid- point	8.0	4.5	1.0	.75	2.5	3.0
Percentage of the Average to Which the Amplitude of Variation Amounts	14.0	23.6	13.6	17.0	20.7	20.0

TABLE V.—DATA FOR *Oceanites oceanicus*

	WING	TAIL	EXPOSED CULMEN	WIDTH OF BILL AT BASE	TARSUS	MIDDLE TOE AND CLAW
Percentage of the Average to Which the Amplitude of Variation Amounts in 97 Specimens from the Atlantic Ocean, Including Juvenal Birds and Molting Adults	14.0	26.0	17.0	32.0	16.0	10.0

A comparison of single full-grown skeletons of *Pelecanoides georgicus* and *Pelecanoides urinatrix urinatrix* shows more clearly than the skins that the New Zealand form is the larger, stouter bird, the differences of size being especially perceptible in the sacrum and sternum. *Pelecanoides georgicus* has broader palatines than the Old World representative, but all other elements of the skull are larger in the latter species. The maxillary and mandibular bones reveal the diagnostic differences in the formation of the bill. The number of vertebræ is the same in the two species, viz., presacral, 21; sacral, 12; coccygeal, 9. It is of much interest that *Alle alle* has also the same number and arrangement of vertebræ.

The following table records comparative measurements in millimeters of the skeletons of two adult diving petrels (*Pelecanoides*

TABLE VI

	<i>Pelecanoides georgicus</i>	<i>Pelecanoides u. urinatrix</i>	<i>Alle alle</i>
Extreme Length of Skull	48.2	51.0	51.0
Greatest Breadth of Brain-case	18.0	19.0	20.0
Length of Spinal Column	120.0	138.0	146.0
Axial Length of Sacrum	24.0	27.0	31.0
Sternum, Manubrium to Posterior End of Keel	36.0	39.6	55.5
Length of Coracoid	22.0	24.0	21.2
Wing	119.7	127.2	124.0
Proximal Element (humerus)	42.0	44.0	42.0
Mesial Element	34.5	35.0	38.0
Distal Element (manus)	43.2	48.2	44.0
Hind Limb	113.6	120.1	120.0
Proximal Element (femur)	22.6	23.8	28.0
Mesial Element (tibia, excluding cnemial crest)	40.0	41.7	44.0
Distal Element (tarsometatarsus and middle toe)	51.0	54.6	48.0

georgicus, Brooklyn Mus., 11274, South Georgia, and *Pelecanoides urinatrix urinatrix*, U. S. Nat. Mus., 18771, New Zealand), and an adult dovekie (*Alle alle*, Brooklyn Mus., 11273, Long Island, N. Y.).

The length of the distal segment of the wing inclusive of the flight feathers, i.e., the ordinary "wing" measurement of descriptive ornithology, averages 113 mm. in 185 adult specimens of *Pelecanoides georgicus*. The same dimension in *Alle alle* may be reckoned at 118 mm., a figure derived by taking the approximate mid-point between the extreme measurements (114–121.5 mm.) given for the wing of this species in Ridgway's 'Manual of North American Birds' (1900). Notwithstanding the considerably longer, stouter ribs of *Alle*, which together with the indicated greater length of its vertebral column and sternum, give it a torso a third larger and doubtless more than a third heavier than that of *Pelecanoides georgicus*, the latter would seem, so far as can be judged from the tabulated figures, to have relatively the more efficient organ of flight. We lack, however, the data to determine to what extent the comparatively shorter wing of *Alle* may be compensated for by a power unit of larger muscles and a greater expenditure of energy. Unfortunately, we have no records of the weights of these two species in the flesh. The area of the expanded wing of a single adult specimen of *Pelecanoides georgicus*, computed by means of a planimeter, is 69.7 square centimeters. That of *Alle alle*, likewise based upon one specimen, is 64 square centimeters.

The "whirr-flight" of diving petrel and dovekie rather resembles that of short-winged gallinaceous birds, such as *Colinus*. It will be of interest, therefore, to compare certain mechanical features of the wing which are shared to some extent by these three widely separated genera, and to contrast the ratios of the proximal and distal alar elements with ratios of the same sort worked out for other birds of not too dissimilar size but exemplifying distinctly different types of flight. A tern and representatives of two long-winged subfamilies of the Tubinares may serve for the latter group. In the following table the length of "manus"

TABLE VII.—LENGTH OF WING ELEMENTS IN MILLIMETERS

	HUMERUS	MANUS	"WING"
<i>Pelecanoides georgicus</i>	42	43	113
<i>Alle alle</i>	42	44	117
<i>Colinus virginianus</i>	36	34	114
<i>Gygis crawfordi</i>	51	68	240
<i>Oceanodroma leucorhoa</i>	37	43	154
<i>Oceanites oceanicus</i>	23	37	145

refers to the distal skeletal unit of the wing, from carpus to the tip of the longest phalanx; "wing," on the other hand, means the distal unit inclusive of the primary quills, as described above.

These data may be reduced to easily comprehensible ratios by dividing the lengths of "wing" and manus, respectively, by the length of the humerus. Then,

$$\text{Alar-humeral ratio} = \frac{\text{"wing"}}{\text{humerus}}$$

$$\text{Mano-humeral ratio} = \frac{\text{bony manus}}{\text{humerus}}$$

TABLE VIII

	ALAR-HUMERAL RATIO	MANO-HUMERAL RATIO
<i>Pelecanoides georgicus</i>	2.69	1.02
<i>Alle alle</i>	2.79	1.05
<i>Colinus virginianus</i>	3.17	.94
<i>Gygis crawfordi</i>	4.71	1.33
<i>Oceanodroma leucorhoa</i>	4.16	1.16
<i>Oceaniles oceanicus</i>	6.30	1.61

It is interesting to note that in these six rather diverse species the ratios between distal and proximal elements of the wing, when the flight feathers are involved, vary vastly more than the ratios between skeletal elements alone. Phylogenetic and mechanical differences in the mechanism of the wings lie therefore mainly in epidermal modifications. The range of the mano-humeral ratios in the two groups, while noticeable, and doubtless not without important relations to the expenditure of energy during flight, is far less striking than that of the alar-humeral ratios. We have not tabulated the relative lengths of the mesial or ulnar element because its significance in the case of the six species under consideration appears to be of lesser importance. Among large Tubinares, such as the albatrosses, however, the marked lengthening of the mid-wing doubtless has a profound effect upon flight.

Aside from the proportions of the wings, the chief structural adaptations of *Pelecanoides georgicus* and *P. urinatrix* to their auklet-like mode of life are to be seen in the caudad extension of the primitive tubinarine sternum and rib-basket. The lower segments of the ribs are extraordinarily lengthened, meeting the superior segments at an acute angle.

s in *Alle*. The pectoral arch has been strengthened through the interlocking of the lower end of the furculum with the anterior tip of the rista sterni. In our single skeleton of *Pelecanoides georgicus*, the furculum is slightly asymmetrical and the right clavicle appears to have sustained an injury during development. The skeleton of *Alle alle*, with its longate sternum, to which is appended an ossified ensiform membrane for the further support of the viscera, its shorter, heavier coracoids, more compact sacrum, and the almost complete "ribbing-in" of the entire thoraco-abdominal cavity, represents, in so far as the axial architecture of the bird is concerned, a higher, structurally superior adaptation to resisting the forceful impact and pressure of water during plunges from light and subsurface progression, habits of life which it shares with *pelecanoides*.

Subgenus **PELECANOIDES** Lacépède

Pelecanoides urinatrix urinatrix Gmelin

Diving Petrel, FORSTER, 1777, 'Voy.,' I, p. 189.

uffinuria urinatrix GOULD, 1844, 'Birds Australia,' VII, Pl. LX.

elecanoides urinatrix COUES, 1866, Proc. Acad. Nat. Sci. Philadelphia, XVIII, p. 190. BULLER, 1873, 'Birds New Zealand,' p. 313; 1888, 'Birds New Zealand,' II, p. 207; 1905, 'Suppl. Birds New Zealand,' I, p. 126. HUTTON, 1874, Ibis, p. 41. RAMSAY, 1888, 'List Australian Birds,' p. 24. SALVIN, 1896, 'Cat. Birds Brit. Mus.,' XXV, p. 437. GODMAN, 1910, 'Monogr. Petrels,' p. 299 (part). LITTLE, 1910, 'Handbook Birds Tasmania,' p. 184 (part). LUCAS AND LE SOUËF, 1911, 'Birds Australia,' p. 64. NORTH, 1914, 'Nests and Eggs Birds Australia and Tasmania,' IV, p. 376.

elecanoides berardi BULLER, 1888, 'Birds New Zealand,' II, p. 208 (part).

aladroma urinatrix SANDAGER, 1889, Trans. New Zealand Inst., XXII, p. 289.

GOULD, 1865, 'Handbook Birds Australia,' II, p. 483.

elecanoides exsul BULLER, 1905, 'Suppl. Birds New Zealand,' I, p. 127 (part).

elecanoides urinatrix urinatrix MATHEWS, 1912, 'Birds Australia,' II, p. 234 (part).

MATHEWS AND IREDALE, 1913, Ibis, p. 237.

elecanoides urinatrix belcheri MATHEWS, 1912, Austral Avian Record, I, p. 84; 1913, 'List Birds Australia,' p. 41.

TYPE SPECIMEN.—Not known, but figured in black and white by Forster.

TYPE LOCALITY.—Queen Charlotte Sound, at northern end of South Island, New Zealand.

GEOGRAPHIC RANGE.—New Zealand (North Island, South Island, Stewart Island), southeastern Australia (New South Wales, Victoria, South Australia), Tasmania, and adjacent seas.

GENERAL CHARACTERS.—Differs from any of the preceding species in striking characters listed under the description of the subgenus. Size approximately that of *elecanoides murgellini*. Natal down gray.

ADULTS (SEXES ALIKE).—Upper parts glossy black; scapulars deep neutral gray, with a whitish terminal bar; wings glossy black, more or less tinged with

brownish, especially on primaries; inner webs of primaries clove-brown, lighter on under surface; secondaries sometimes narrowly tipped with whitish; under wing-coverts whitish, more or less washed with light mouse-gray, the shafts dark; rectrices glossy black, fading to blackish brown, paler on the under surface; anterior part of forehead and lores suffused with clove-brown; under parts white; feathers of auricular and malar regions, and sides of neck and breast, deep neutral gray, for the most part narrowly tipped with white, giving a somewhat barred appearance; jugulum obscurely mottled with neutral gray, which sometimes forms an indistinct collar; axillaries dark mouse-gray, tipped with whitish; sides and flanks washed with deep neutral gray, the feathers tipped with whitish; feathers of tibia dark mouse-gray; down plumules and aftershafts over entire body deep mouse-gray. Paraseptal processes situated posterior to the longitudinal center of the septum and not prominently developed. "Irides and bill black; legs and feet cobalt, tinged with green, the webs bluish white" (Buller).

Adult Male.—Length (skins), 182–208 (196.6); wing, 116–133 (122.6); tail, 34.5–41 (38); exposed culmen, 15.5–16.5 (16.2); width of bill, 7.5–8.5 (8.1); depth of bill, 6.5–7 (6.8); tarsus, 25–28 (26.1); middle toe and claw, 29–35 (31.9).¹

Adult Female.—Length (skins), 189–212 (198); wing, 112–123 (116.8); tail, 35–38 (36.5); exposed culmen, 16–17 (16.4); width of bill, 8–8.5 (8.1); depth of bill, 6–7.5 (6.7); tarsus, 24–28 (25.3); middle toe and claw, 29.5–33 (31.3).²

NESTLING.—"Covered with sooty-gray down; head and neck nearly bare; black feathers first appear on the wings" (Buller).

SPECIMENS EXAMINED.—Total number, 25, as follows:

New Zealand: Hauraki Gulf, 2³; Karewa Island, 1⁴; Stephens Island, 3⁵; Otago, 16; near Dunedin, 1⁷; Invercargill, 1⁸; Foveaux Straits, 1⁷; Stewart Island, 3^{8, 9}; no specific locality, 5. ^{3, 8}

Tasmania, 4. ³

Locality unknown, 3. ^{3, 9}

NESTING SEASON.—June, July, August (Bass Strait, Buller, *loc. cit.*, p. 208; August (White Rock, east coast of Tasmania, North, *loc. cit.*, p. 376); October, November, December (islands of Bass Strait, and those off northwestern and southern Tasmania, North, *loc. cit.*, p. 376); July, August (Mokohinou Islands, N. Z., Sandager, *loc. cit.*, p. 389).

EGG.—"The eggs vary in shape from oval to rounded oval; others are nearly a true ellipse in form, and some are somewhat abruptly pointed at one end, the shell being close-grained, dull and lustreless. When newly laid they are pure white, but some become more or less stained and soiled, and are of a dirty leaden-hue as they approach the time of hatching" (North). Average specimens from the islands in Bass Strait measure, 37.6×31.2, 40.6×30.5, 38.9×30.5, 42.4×33, 43.9×33, 43.2×32.5, 46.5×33.5¹⁰ (average, 41.9×32). Lucas and Le Souëf give the measure-

¹Seven specimens, from New Zealand.

²Five specimens, from New Zealand.

³Collection Zool. Mus., Tring.

⁴Collection Pub. Mus., Milwaukee.

⁵Collection Carnegie Mus.

⁶Collection Calif. Acad. Sci.

⁷Collection U. S. Nat. Mus.

⁸Collection Brit. Mus.

⁹Collection Boston Soc. Nat. Hist.

¹⁰Measurements originally given in inches and hundredths; here converted into millimeters.

ments 41×31 . New Zealand eggs measure 38.1×30.5^1 (Portland Island, Buller), and 38.1×31.7^1 (Mokohinou Islands, Sandager).

The diving petrels of Australia and Tasmania have been separated by Mathews under the name of *Pelecanoides urinatrix belcheri*, the supposed subspecific characters being diagnosed as follows: "Differs from *P. u. urinatrix* in being smaller, and in having the under surface of the wings whiter and the grey of the breast not joined in a band. The nostrils are also larger."² Our examination of the type and three other specimens in the Mathews collection (all of which are labeled "Tasmania") has failed to reveal any essential character that can not be practically matched in New Zealand specimens. The average measurements of the four specimens are: length (skins), 198.5; wing, 120.7; tail, 40.2; exposed culmen, 16.5; width of bill, 7.9; depth of bill, 6.1; tarsus, 25.9; middle toe and claw, 31.5.

Buller reports that this diving petrel is "very common in the seas surrounding New Zealand, consorting in flocks, and living on medusæ and other marine productions. It is especially abundant at all seasons in the Gulf of Hauraki." He goes on to say that its flight is rather labored, consisting of a rapid fluttering movement along the surface of the water, but Hutton (*loc. cit.*, p. 41) states that this description is quite incorrect, and that the "bird flies very fairly."

Buller's account continues as follows:

They swim in the sea with the head much uplifted, and are very active on the water.

Some years ago, during a severe gale, many hundreds of them were cast ashore in the Bay of Plenty, and it was observed that a number of them were afflicted with a large flat tick measuring .25 of an inch across the body and legs.

The stomach of one I opened contained black comminuted matter and one or two small seeds, apparently of some kind of seaweed. I observed that the skin of this bird was very tough and thick, the roots of the feathers appearing underneath as in the Penguins and some other birds.

The young birds are so fat that it may truly be said of them that a wick inserted through the body of a dead one will burn as steadily as if in a lamp!

Mr. Burton found this Petrel breeding on Stephens' Island, in Cook's Strait. It also breeds on Karewa Island (off Tauranga), on the small islets of the Great Barrier, and on the "Hen and Chickens."

Sandager, writing of the species at the Mokohinou Islands, contributes the following information.

Breeds on three of the smaller, comparatively low, islands, where it forms its burrow in the peat-like substance, consisting of light soil and decayed *Mesembryanthemum*, with which they are covered. Burrowing commences in April. In July

¹Measurements originally in inches and hundredths; here converted into millimeters.

²1912, *Austral Avian Record*, I, p. 84.

a nest, consisting of dry flax, sticks, and grass, is formed at the end of the burrow, and a few of the earlier birds begin to lay during the last half of the month, but most of the laying takes place during August. The birds, previous to laying, are rarely found in the burrows during the day, all the work of burrowing, etc., being carried on at night. One egg only is laid in each nest.

Gould's account of this petrel is as follows:

I observed that this curious little bird was very abundant in Storm Bay, and off many parts of the coast of Van Diemen's Land. . . . It possesses none of those great powers of flight common to the rest of the family [i.e., order], but has this loss amply compensated for by its powers of diving, which are so great that it is even said to fly under water. It thus gives chase to shrimps and other small crustaceans, fry of fish, etc., upon which it feeds; and in turn finds a destroying enemy in the Barracoota, a ravenous fish so called by the colonists, and which is very common in the seas off the southern parts of Australia. Its flight is a curious fluttering motion, performed so close to the surface that it rarely rises high enough to top the waves, but upon being met by them makes progress by a direct course through instead of over them.

Littler reports that it breeds on one of the islands of the Kent group, in Bass Strait.

Buller quotes Mr. A. J. Campbell, who writes:

On some isolated islets in Bass's Strait, Diving-Petrels are numerous. They generally remain in the vicinity of these rocks, but at times disappear for two or three months. During June and July the birds come ashore to scrape out or prepare their nest-burrows. The laying-season occurs about the end of July, and continues for about a fortnight. Each female bird deposits one egg only in a burrow, which is from 6 to 8 inches deep, under ground or under a ledge of rock.

The information quoted below is from North's exhaustive work on the nests and eggs of Australian and Tasmanian birds.

The single egg of this species is deposited at the enlarged end of a burrow in the earth, or sandy soil, from one to two feet in length; sometimes these burrows are branched, and in them have been frequently found pairs of birds. Diving Petrels were found breeding on North-east Island . . . in Bass Strait, during November, 1890, . . . the burrows at that time containing mostly young birds nearly fledged.

October, November and December are the usual breeding months on the islands of Bass Strait, and those off the North-western coast of Tasmania and Southern Tasmania. That this Petrel may breed a second time, or possibly another colony of birds may have a different breeding time, is proved by Mr. Oldham finding it laying in August, 1907, on the White Rock,¹ on the eastern coast of Tasmania.

From the foregoing accounts it appears that this diving petrel, like *P. garnoti*, has a decidedly prolonged or variable nesting season. It is perhaps significant, in this connection, that these two forms have warmer habitats than any of the other diving petrels whose nesting seasons are definitely known. It is natural that the reproductive season of the forms inhabiting the colder regions should be more definitely limited to the months of the subantarctic summer.

¹A fresh egg was collected at this place on August 22, 1907.

***Pelecanoides urinatrix chathamensis* Murphy and Harper**

Haladroma urinatrix GOULD, 1865, 'Handbook Birds Australia,' II, p. 483 (part).

Pelecanoides berardi BULLER, 1888, 'Birds New Zealand,' II, p. 208 (part). FORBES, 1893, *Ibis*, p. 542.

?*Pelecanoides* species CHILTON, 1909, 'Subantarctic Islands New Zealand,' II, p. 566.

Pelecanoides urinatrix FORBES, 1893, *Ibis*, p. 541. BULLER, 1905, 'Supplement Birds New Zealand,' I, p. 126 (part). GODMAN, 1910, 'Monogr. Petrels,' p. 299 (part).

Pelecanoides exsul GODMAN, 1910, 'Monogr. Petrels,' p. 304 (part).

Pelecanoides urinatrix urinatrix MATHEWS, 1912, 'Birds Australia,' II, p. 234, (description and plate).

Pelecanoides urinatrix chathamensis MURPHY AND HARPER, 1916, *Bull. Amer. Mus. Nat. Hist.*, XXXV, p. 65.

TYPE SPECIMEN.—No. 151112, U. S. National Museum; adult male; collected in February 1893; received from S. Dannefaerd.

TYPE LOCALITY.—Chatham Islands.

GEOGRAPHIC RANGE.—Chatham Islands, Snares Island, Auckland Islands, and adjacent waters; probably also Bounty and Antipodes Islands.

SUBSPECIFIC CHARACTERS.—Similar to *Pelecanoides urinatrix urinatrix*, but averaging smaller in practically all dimensions, particularly bill and wing.

Adult Male.—Length (skins), 182–196 (186.8); wing, 110–114 (112.4); tail, 34–39 (36.5); exposed culmen, 14–16 (15.2); width of bill, 7–8 (7.4); depth of bill, 5–6.5 (6); tarsus, 24–26 (24.9); middle toe and claw, 29.5–33 (31).¹

Adult Female.—Length (skins), 175–187 (179.3); wing, 109.5–116.5 (113); tail, 34.5–40 (37.8); exposed culmen, 14.5–15.5 (15.2); width of bill, 7–7.5 (7.3); depth of bill, 6; tarsus, 24; middle toe and claw, 29–30 (29.7).²

NESTLING.—Mesotyle down mouse-gray on upper surface of the body, light mouse-gray beneath.

SPECIMENS EXAMINED.—Total number, 21, as follows:

Chatham Islands, 17.^{3, 4, 5, 6}

Snares Island, 2.⁷

Auckland Islands, 2.^{6, 7}

NESTING SEASON.—"I have obtained information on good authority of eggs being collected after August 15th which contained embryos, and fresh eggs again in October" (Seymour, cf. Buller, *loc. cit.*, p. 208).

EGG.—"The eggs vary in form from oval to nearly round and are more or less pointed at one end; ground-color white. Dimensions: 35.6×29.2, 35.6×27.9, 38.1×27.9, 34.3×27.9, 35.6×29.2, 33×27.9, 38.1×28.2, 36.8×29.2, 33×27.9"⁸ (Forbes, *loc. cit.*, p. 541); average, 35.6×28.4.

At the time the writers described this subspecies, the small amount of material available showed a decided difference in dimensions between Chatham Island birds and New Zealand birds. While this difference is

¹Six specimens: four from Chatham Islands, one from Snares Island, and one from Auckland Islands.

²Three specimens, from Chatham Islands.

³Collection Zool. Mus., Tring.

⁴Collection Acad. Nat. Sci. Phila.

⁵Collection U. S. Nat. Mus.

⁶Collection Carnegie Mus.

⁷Collection Brit. Mus.

⁸Measurements converted from inches and hundredths into millimeters.

less striking in the much larger series of specimens that have since been examined, it still appears sufficient, in the case of practically all specimens with authentic data, to separate *chathamensis*. It is noteworthy in this connection that a large proportion of the indigenous birds of the Chatham Islands, which lie about 500 miles east of New Zealand, have been found to be distinct from their counterparts of the latter insular "mainland."

The diver from Snares Island and the smaller of the two forms found at the Auckland Islands also seem referable to *chathamensis*. The smaller size of *chathamensis*, as compared with *urinatrix*, is apparently correlated with the lower mean annual temperature of the islands it inhabits and with their greater proximity to the limit of floating icebergs. This form may also be expected on Bounty and Antipodes Islands, where climatic conditions are probably intermediate between those at the Chatham Islands and at the Auckland Islands.

The occurrence of more than one form at a single locality, such as the Auckland Islands, is very exceptional in this family. The distinctness of Auckland Islands specimens of *P. u. chathamensis* and *P. exsul* may be judged, in part, from the following average dimensions of two specimens of the former and three specimens of the latter, the measurements of *chathamensis* being given first: length (skins), 184.5, 208.3; wing, 110.5, 119.8; tail, 37.5, 38.5; exposed culmen, 13.7, 16; width of bill, 7.2, 8.7; depth of bill, 6.2, 6.5; tarsus, 24.7, 26.2; middle toe and claw, 29, 33.5. The specimens of *exsul* are further distinguished by bill characters and by the much heavier and more uniform mottling of the jugulum.

The Chatham Island diving petrel may be the form which Gould (1844, 'Birds Australia') saw at sea "about 20 degrees to the eastward of New Zealand, taking mollusks from the surface of the ocean."

Waite, in Chilton's 'Subantarctic Islands of New Zealand,' writes as follows of birds seen near one of the islands.

. . . we found the water to be dotted with little diving-petrels. . . . By repeatedly diving and swimming under water these little birds failed to increase their distance from the boat, and they took to wing. In rising from the water they used their legs with a paddling action, flew a short distance with a seemingly labored or erratic flight, and then dropped on to the water at a supposedly safe distance.

***Pelecanoides urinatrix berard* (Quoy and Gaimard)**

Plates XXII, Figure 2, XXIV, Figure 2

Procellaria bérard QUOY AND GAIMARD, 1824, 'Voy. Uranie, Zool.,' p. 135, Pl. xxxvii.

Pelecanoides berardi ABBOTT, 1861, *Ibis*, p. 164.

Pelecanoides garnoti OATES, 1901, 'Cat. Birds' Eggs Brit. Mus.,' I, p. 161 (part).

Pelecanoides urinatrix GODMAN, 1910, 'Monogr. Petrels,' p. 299 (part).

P[elecanoides] urinatrix berard MATHEWS, 1912, 'Birds Australia,' II, p. 238.

TYPE SPECIMEN.—Not known, but figured by Quoy and Gaimard.

TYPE LOCALITY.—At sea, near the Falkland Islands.

GEOGRAPHIC RANGE.—Falkland Islands north to the coast of the Province of Buenos Aires, Argentina.

SUBSPECIFIC CHARACTERS.—Size approximating that of *P. u. urinatrix*, but generally with smaller bill, longer tail, and longer middle toe and claw. The mottling across the jugulum is more pronounced than in *P. u. urinatrix*, less pronounced than in *P. u. dacunhae*, and not so dense and extensive as in *P. exsul*.

Iris brown, bill black, feet blue with blackish webs (R. H. Beck, label).

Adult Male.—Length (skins), 195–227 (208.2); wing, 117.5–125.5 (121.1); tail, 39.5–46 (42.7); exposed culmen, 15–16 (15.5); width of bill, 7–8 (7.4); depth of bill, 6–6.5 (6.2); tarsus, 24.5–27 (25.7); middle toe and claw, 32–36.5 (33.4).¹

Adult Female.—Length (skins), 198–201 (199.3); wing, 117–123 (120.5); tail, 40–44 (41.5); exposed culmen, 15.5–16 (15.7); width of bill, 7.5–8 (7.7); depth of bill, 6; tarsus, 25–25.5 (25.2); middle toe and claw, 32–33 (32.5).²

NESTLING.—Not seen.

SPECIMENS EXAMINED.—Total number, 12, as follows:

Falkland Islands: Kidney Island, 5³, 4; Cuchon Island, 1³; no specific locality, 5.⁴

Argentina: offshore, between San Mathia and Necochea, 1.⁵

NESTING SEASON.—Sitting on egg in November (R. H. Beck, label).

EGG.—Two collected at Kidney Island, in November 1915, are respectively rounded ovate, or almost subspherical, and elliptical ovate; white, lusterless; measurements, 35.2×31, 38.8×29.5 (average, 37×30.3). Average volume of the two, 16.7 cubic centimeters.

Under the name *P. garnoti*, Oates (*loc. cit.*, p. 161) records two eggs from the Falkland Islands and one from Kerguelen. The dimensions for the three are 39.4×30.9; 39.4×31.75, and 40.9×33, but unfortunately the author does not designate the Falkland specimens.

It was only after the writers had long been familiar with large series of specimens of *P. garnoti*, *P. magellani*, and *P. georgicus*, representing, respectively, the subgenera *Puffinuria*, *Porthmornis*, and *Pelagodyptes*, that they eventually had access to a few specimens from the Falkland Islands and from the coast of Chile at about latitude 50° S. It was then a matter of no small surprise to ascertain that the birds from these localities represented two forms of the *P. urinatrix* group (*P. u. berard* and *P. u. coppingeri*), subgenerically distinct from all their nearest neighbors. Thus all four subgenera of Pelecanoididæ are found in the Western Hemisphere, whereas only two subgenera, represented by three species, are known from the Old World.

¹Four specimens.

²Three specimens.

³Brewster-Sanford Collection.

⁴Collection Brit. Mus.

⁵Collection Amer. Mus. Nat. Hist.

The description of *Procellaria berard* by Quoy and Gaimard, and all subsequent published references to the Falkland Islands diver, are too incidental to be of any assistance in assigning the form to its proper place within the family. Mathews undoubtedly realized its true position, but presented no evidence in support of his conclusion. Even after Mr. Chubb had kindly supplied us with detailed measurements of six Falkland



Fig. 5. Egg of *Pelecanoides urinatrix berard*, photographed *in situ* by R. H. Beck, after the opening of a burrow at Kidney Island, Falklands, November 6, 1915.

specimens in the British Museum, we were still at a loss as to the affinities of the bird; but the problem was solved, practically at a glance, when Mr. Beck sent five beautifully prepared specimens from the field.

Mr. Beck saw one diving petrel, presumably *Pelecanoides urinatrix berard*, about seventy-five miles due south of the Falkland Islands on one of the latter days of September 1915. On November 6, of that year, he visited Cuchon Island, East Falkland, and found the first burrow, which contained a male diving petrel sitting upon a heavily incubated egg. On the same date he also landed at Kidney Island, which is but four miles from Cuchon, and found a second burrow in a patch of tussock grass (*Poa flabellata*) not far from the water. By digging and pulling out

the manure-like humus around the nest, he managed to obtain a photograph of the sitting bird. The entrance to the nest was under a slab of rock, but the tunnel twisted about for three feet and ended in an enlarged chamber which was lined with a few dry blades of tussock grass. On November 18 he captured three more diving petrels in their nests on Kidney Island. He discovered, moreover, that abandoned *Pelecanoides* burrows are used as nesting sites by the small, dendrocolaptid "tussock-bird" (*Cinclodes*).

On December 16, at Sea Lion Island, Mr. Beck found the foot and leg of a diving petrel within the stomach of a short-eared owl (*Asio flammeus sanfordi* Bangs).

Pelecanoides urinatrix dacunhae Nicoll

Pelecanoides urinatrix VERRILL, 1895, Trans. Connecticut Acad., IX, part 2, p. 449 (part). CLARKE, 1905, Ibis, p. 264; 1913, 'Rep. Sci. Results Voy. Scotia,' IV, part 14, sect. IX, p. 286.

Pelecanoides dacunhae NICOLL, 1906, Bull. B. O. C., XVI, p. 103; 1906, Ibis, p. 674; 1909, 'Three Voyages of a Naturalist,' 2d Ed., pp. xv, xxix.

Pelecanoides exsul GODMAN, 1910, 'Monogr. Petrels,' p. 304 (part).

P. [elecanoides] urinatrix dacunhae MATHEWS, 1912, 'Birds Australia,' II, p. 238.

TYPE SPECIMEN.¹—No. 1906. 12. 21. 58, British Museum; adult female; collected January 17, 1906, by M. J. Nicoll.

TYPE LOCALITY.—The shore waters of the island of Tristan da Cunha.

GEOGRAPHIC RANGE.—Tristan da Cunha, Gough Island (?), and adjacent waters.

SUBSPECIFIC CHARACTERS.—Apparently most closely allied to *P. u. berard*, but with generally smaller dimensions. Feathers of cheeks, sides of neck, and jugulum with conspicuous, dark brownish shafts.

ADULT FEMALE.²—Upper parts glossy black, largely faded and worn to dull blackish brown; scapulars grayish white, with broad subterminal band of deep neutral gray, darker on outer web; scapulars more or less overlaid and concealed by dark interscapulars; wings glossy black, largely faded and worn to blackish brown, especially on the primaries; a faint indication of light edging to secondaries, but practically lost through wear; under wing-coverts white, strongly washed with deep neutral gray, the shafts of the feathers dark for practically their entire length; rectrices blackish brown, with a slight gloss, and paler on under surface; lores and anterior part of forehead suffused with clove-brown; under parts white; cheeks and sides of neck deep neutral gray, the feathers narrowly tipped with white; this gray mottling extending across the jugulum, though faint in the middle; feathers of the mottled parts (cheeks, sides of neck, and jugulum) with conspicuous, dark brownish

¹The original describer did not designate a type specimen but used as cotypes two adult females in the British Museum, both collected at Tristan da Cunha on January 17, 1906. We find, however, that the label of No. 1906. 12. 21. 58 is marked "Type," and accordingly we hereby designate this specimen as the type.

²Description of the type, which is in worn and faded plumage.

shafts (these being especially prominent in the cotype; likewise evident, but not so striking, in *berard*); axillaries, sides, and flanks strongly washed (or broadly banded) with deep neutral gray, the feathers with conspicuous blackish shafts; feathers of tibia deep mouse-gray; down plumules and aftershafts mouse-gray. Paraseptal processes situated posterior to the longitudinal center of the septum. "Bill black, a blue streak on upper mandible at gape; tarsi and toes bright blue, webs blackish."¹

Adult Female.—Length (skins), 202–204 (203); wing, 108–113 (110.5); tail, 36.5–37 (36.7); exposed culmen, 15.5–16.5 (16); width of bill, 7; depth of bill, 5–5.5 (5.2); tarsus, 24; middle toe and claw, 29–31 (30).²

NESTLING.—Not seen.

SPECIMENS EXAMINED.—Total number, 2,³ both from Tristan da Cunha.

NESTING SEASON.—A single egg from Gough Island was collected between September and January.

EGG.—40×29.5⁴(Gough Island).

Most of our information concerning this little-known form of *Pelecanoides* is contained in the following account by Nicoll.⁵

The most interesting birds which we saw, however, were some diving petrels, which proved to belong to a species not hitherto recorded from Tristan da Cunha. Superficially these petrels resemble the diving petrel of the Straits of Magellan, but they are somewhat smaller and have a much greater power of flight. On several occasions I saw them rise off the water and fly away out of sight, whereas those found in the Magellan Straits drop into the water after a flight of about fifty to one hundred yards. The Tristan da Cunha diving petrels are constantly exposed to rough weather and breaking waves, and in consequence have to take wing continually to avoid being drowned, and this fact may account for their greater powers of flight.

They were met with soon after we left the yacht, and became more numerous as we approached the land. Half a mile from the shore they were on all sides of us, and appeared continually close to the boat, when instead of diving they at once took to flight, and passed away at a great speed.

It is perhaps significant that Mrs. K. M. Barrow⁶ makes no reference to this species in a list of birds observed by her during a long residence at Tristan. Nicoll's statement that the island is over-run with rats suggests the possibility that the burrowing *Pelecanoides* have been forced to confine their nesting to some of the neighboring and uninhabited islands of the Tristan group. (Cf. *P. georgicus*, p. 523.)

The specimen taken by the 'Scotia' expedition off Gough Island, 250 miles distant from Tristan, probably belongs to the same form.

¹Nicoll, notation on label of the type. W. Eagle Clarke (Ibis, 1905, p. 264) states of a Gough Island specimen that "the tarsus and toes in life are cobalt-blue and the webs and claws black."

²Two specimens. The type has the smaller measurements in wing, culmen, depth of bill, and middle toe and claw.

³Collection Brit. Mus.

⁴Converted into millimeters from Verrill's measurements in inches. An "egg from Gough Island, marked 'supposed to be a diver,' measures 1.57×1.16," (Verrill). The width is copied by mistake as 1.6 inches by Clarke (Ibis., loc. cit., and Rep. Sci. Results 'Scotia,' loc. cit.).

⁵1909, 'Three Voyages of a Naturalist,' pp. 67, 68.

⁶1910, 'Three Years in Tristan da Cunha,' p. 275.

The measurements of the egg secured on Gough Island by Comer would not be likely to apply to the egg of any bird, other than a *Pelecanoides*, that nests there.

***Pelecanoides urinatrix coppingeri* Mathews**

Pelecanoides urinatrix SALVIN, 1896, 'Cat. Birds Brit. Mus.,' XXV, p. 437 (part).

GODMAN. 1910, 'Monogr. Petrels,' p. 299 (part).

P[elecanoides] urinatrix coppingeri MATHEWS, 1912, 'Birds Australia,' II, p. 238.

TYPE SPECIMEN.—No. 80.8.3.30, British Museum; adult female; collected October 16, 1879, by Dr. R. W. Coppinger.

TYPE LOCALITY.—Cockle Cove, Pilot Island, Trinidad Channel, Chile (latitude 50° 5' S., longitude, 75° 3' W.).²

GEOGRAPHIC RANGE.—Known definitely only from Cockle Cove, Trinidad Channel, and Cove Harbor, Messier Channel, Chile.

SUBSPECIFIC CHARACTERS.—Apparently nearest to *P. u. berard*, but averaging smaller; scarcely any trace of mottling across the jugulum, as in *berard* and *dacunhae*.

Adult (Male?).—Length (skin), 193; wing, 116; tail, 41; exposed culmen, 16; width of bill, 7; depth of bill, 6; tarsus, 25; middle toe and claw, 31.³

Adult Female.—Length (skins), 165–206 (185.5); wing, 106–111 (108.5); tail, 36–38 (37); exposed culmen, 15.5–16 (15.7); width of bill, 7; depth of bill, 5.5; tarsus, 25–25.5 (25.2); middle toe and claw, 31.⁴

NESTLING.—Not seen.

SPECIMENS EXAMINED.—Total number, 4,⁵ as follows:

Chile: Cove Harbor, Messier Channel, 2; Cockle Cove, Trinidad Channel, 1; (? 'Strait of Magellan,' 1).

NESTING SEASON.—Unknown.

EGG.—Not seen.

The distribution of this diving petrel is interesting. It is evidently a subspecies of the *P. urinatrix* group, being not easily separable from *berard*. Yet between the known ranges of the two forms lies almost the entire habitat of *P. magellani*.⁶ *P. u. coppingeri*, in turn, seems to occupy an area intermediate between the ranges of *P. garnoti* and *P. magellani*. Except for the occurrence of both *P. u. coppingeri* and *P. magellani* in the Trinidad Channel, the ranges of the four subgenera of *Pelecanoides* are apparently quite distinct.

It is rather probable that the range of the present form extends to the northern limit of the inland waterways of Chile, or to about latitude

¹Not designated in the original description, but in a letter from Mr. Mathews to the senior writer.

²The locality given on the label is "Cockle Cove, Magellan." Apparently in Dr. Coppinger's time the name Magellan was loosely applied to a much larger region than nowadays.

³One specimen.

⁴Two specimens.

⁵Collection Brit. Mus.

⁶Whether the specimen from the "Strait of Magellan" came actually from the strait itself, is not determinable. (Cf. foot-note 2, above.) Moreover, it might be referred almost as readily to one as to the other of the two very similar forms, *berard* and *coppingeri*.

41° 40' S. Darwin's record of diving petrels in the Chonos Archipelago has already been mentioned (p. 516). It may likewise be assumed that the following notes from Mr. Beck's journal refer to *coppingeri*.

Early July, 1914. Diving petrels common between Ancud and Puerto Montt, Gulf of Chacao, Chile. A few seen later in the Pacific about thirty miles off Guamblin Island (44° 45' S.), and again off the Gulf of Penas (47° 30' S.).

Pelecanoides exsul Salvin

Pelecanoides urinatrix COUES AND KIDDER, 1875, Bull. U. S. Nat. Mus., No. 2, p. 36.

KIDDER AND COUES, 1876, idem, No. 3, p. 17. SALVIN, 1881, 'Challenger Reports, Zool.,' II, part 2, p. 146. WYVILLE THOMSON, 1885, editor, 'Challenger Reports, Narrative,' I, part 1, p. 359. MOSELEY, 1892, 'Notes Naturalist Challenger,' p. 181. VERRILL, 1895, Trans. Connecticut Acad., IX, part 2, p. 449. OATES, 1901, 'Cat. Birds' Eggs Brit. Mus.,' I, p. 161.

Pelecanoides exsul SALVIN, 1896, 'Cat. Birds Brit. Mus.,' XXV, p. 438. HALL, 1900.

Ibis, p. 30. WILSON, 1907, 'Nat. Antarct. Exp., Zool.,' II, part 2, p. 107. GODMAN, 1910, 'Monogr. Petrels,' p. 304 (part).

P[elecanoides] urinatrix exsul MATHEWS, 1912, 'Birds Australia,' II, p. 238.

Diver, DU BATY, 1912, 'Fifteen Thousand Miles in a Ketch,' p. 180.

TYPE SPECIMEN.—Not designated, but in the collection of the British Museum.

TYPE LOCALITY.—Here fixed at Kerguelen Island.¹

GEOGRAPHIC RANGE.—Crozet Islands, Kerguelen Island, Auckland Islands, and waters adjacent to each.

GENERAL CHARACTERS.—Distinguished from all forms of *P. urinatrix* by the following: average greater width of bill; mandibular rami not quite so nearly parallel; anterior ends of gnathidia turned inward more at lower edge, bringing the tips of these elements closer together at the symphysis, and disclosing their surfaces more broadly to view from the ventral aspect; jugulum more heavily and distinctly mottled with deep neutral gray.

ADULTS (SEXES ALIKE).—Upper parts glossy black; scapulars deep neutral gray, with a whitish terminal bar; wings glossy black, more or less tinged with brownish, especially on primaries; inner webs of primaries clove-brown, lighter on under surface; secondaries narrowly tipped with whitish; under-wing-coverts whitish, more or less washed with light mouse-gray, the shafts dark; rectrices glossy black, fading to blackish brown, paler on the under surface, and the worn tips with a trace of whitish; anterior part of forehead and lores suffused with clove-brown; under parts white; feathers of auricular and malar regions, and sides of neck and breast, deep neutral gray, for the most part tipped with white; this mottling extending completely across the jugulum, and becoming only slightly less distinct in the middle; axillaries mouse-gray; sides and flanks washed with deep neutral gray, the feathers tipped with whitish and the shafts dark; feathers of tibia mouse-gray; down plumules and aftershafts over entire body mouse-gray. Paraseptal processes situated posterior to the longitudinal center of the septum and not prominently developed. "Bill generally black:

¹Godman ('Monogr. Petrels,' p. 304) remarks: "Salvin gives no dimensions, so I have not been able to determine from which specimen in the British Museum his description was taken, but I have no doubt that it was from a Kerguelen example; he also includes the birds from the Crozet Islands under the heading of *P. exsul*."

lavender-blue at quadrate basal portion of lower mandible. Iris ash-colored; not visible during life, when only the black pupil appears. Tarsus and foot lavender-blue" (Kidder).

Adult Male.—Length (skins), 189–251 (213.8); wing, 118–121.5 (119.7); tail, 35–40.5 (38.2); exposed culmen, 15.5–17 (16.2); width of bill, 8.5–9.5 (8.9); depth of bill, 6.5–8 (7.1); tarsus, 26–27 (26.4); middle toe and claw, 30.5–36 (33.2).¹

Adult Female.—Length (skins), 205–218 (211.5); wing, 118.5–121 (119.7); tail, 35.5–39.5 (37.5); exposed culmen, 16; width of bill, 9; depth of bill, 6–7 (6.5); tarsus, 26–26.5 (26.2); middle toe and claw, 32–33 (32.5).²

NESTLING.—Mesoptyle down light mouse-gray.

SPECIMENS EXAMINED.—Total number, 28, as follows:

Crozet Islands, 3.^{3, 4}

Kerguelen Island, 20.^{3, 4, 5}

Auckland Islands, 3.^{3, 4}

Locality unknown, 2.^{4, 6}

NESTING SEASON.—October to February.

EGG.—"White, with a few red specks at one end" (Moseley). "Regular ovoid, tending in some specimens to ellipsoidal. . . . Shell is white, thin, brittle, compact, and homogeneous in structure. No color-markings" (Kidder and Coues). Size¹ 41×29.2, 41×32.2, 42×32, 41.9×31.7 (Kidder); average of 4, 41.5×31.3. Verrill gives the dimensions of two as 38.5–39×31–32, and states that the "shell is thin, friable, and rather smooth, but shows shallow depressions under the lens. The shape, in one, is an almost perfect, but very broad, ellipsoid; the other is also very broad but tends somewhat to the ovate form. The color is creamy white, much stained (by contact with the earth?) with dirty yellowish." Oates records the measurements of eight specimens as follows: 33–39×28–33.

Considerable doubt and confusion have existed regarding the status of this diving petrel, even after it was described by Salvin as a distinct species. A long and careful study of the subject has led us to concur with Salvin in according specific rank to *exsul*. This decision is based not only upon the rather slight but doubtless significant differences of plumage and bill structure between this form and *P. urinatrix*, as pointed out above, but also upon the fact that both *P. exsul* and *P. u. chathamensis* occur on a compact group of small islands, the Auckland Islands. In the light of the modern conception of the subspecies, it would be extremely difficult, not to say impossible, to account for the presence of both of these birds on the Auckland Islands if they were no more than subspecifically distinct.

The range of *exsul*, with its narrow latitudinal confines and its great longitudinal extension from the Crozet Islands to the Auckland Islands,

¹Six specimens, from Kerguelen.

²Two specimens, from Kerguelen.

³Collection Brit. Mus.

⁴Collection Zool. Mus., Tring.

⁵Collection U. S. Nat. Mus.

⁶Collection J. H. Fleming.

⁷All measurements originally in inches; here converted into millimeters.

is somewhat analogous to that of *P. georgicus*. The narrow strip of subantarctic seas which it occupies is evidently intermediate between corresponding strips on the north and south occupied, respectively, by various forms of *P. urinatrix* and by *P. georgicus*. So far as known, the Auckland Islands are the only land area where the range of *exsul* overlaps that of another species.

The diving petrel is one of the most abundant breeding birds at Kerguelen Island, making its nest burrow beneath the mounds of an umbelliferous plant (*Azorella selago*) that grows in dense masses on the hillsides. Dr. Kidder found it to be one of the two species most commonly seen and heard at night, the other being *Halobæna*. The note of the *Pelecanoides*, writes Kidder,

is somewhat similar to the mew of a cat, with a marked rising inflection of sound. The bird cannot rise from level ground in flight, but, once in the air, flies strongly and rapidly, with a rapidly fluttering motion of the wings, very like the flight of the common English sparrow. It burrows in the same localities as *Halobæna*, digging less deeply and making fewer turns in its burrow, and seems to remain therein during the day, being exclusively nocturnal in its habits when near its nest. Lays one egg, as large as a pigeon's, white, and not sharply pointed; first found by me December 10. I did not succeed in finding any young up to January 10, the date of our departure.

Du Baty records his impressions of the voice of Kerguelen diving petrel in the following words.

The diver is another night bird, and it has a peculiar cry like the mewing and miauling of a cat. There were times, as I stood on deck in the night watch listening to this bird, when I could almost have believed that I was back in Paris in a room under the attics where the cats were on the prowl and indulging in their witches' chorus.

The 'Challenger' naturalists¹ record the following observations on this petrel.

It is to be seen on the surface of the water in Royal Sound [Kerguelen Island] when the water is calm, in very large flocks. On two days [in January] when excursions were made in the steam pinnace, the water was seen to be covered with these birds in flocks, extending over acres, which were black with them. The habits of the northern Little Auk are closely similar to those of this bird; so close is the resemblance, that the whalers have transferred one of their familiar names for the Little Auk to the Diving Petrel. These Petrels dive with extreme rapidity, and when frightened, rise, flutter along close to the water, and drop and dive again; it is a curious sight to see a whole flock thus taking flight. The birds breed in enormous quantities on the islands in Royal Sound, making holes in the ground like the Prions; they are readily attracted by a light, and some were caught on board through coming to the ship's lights. The single egg is white, with a few red specks at one end.

¹ Moseley and others.

The statement that there are "red specks" at one end of the egg would seem to be an error, for, although recorded on the authority of that most observant and scrupulous naturalist, Professor Moseley, it is at variance with the testimony of all others, both with regard to this species and to diving petrels in general.

Hall found this bird common at Kerguelen in the summer season of 1897-1898, and collected specimens by exposing the ship's light on dark nights.

Dr. Wilson, who lost his life with Scott after the discovery of the South Pole, has recorded the following excellent description of the flight of the diving petrels which he observed in the southern Indian Ocean to 122° east and as far south as 51°.

In mid-ocean one may see a small petrel, quite alone, flying fast and straight close over the wave-tops, until suddenly, like a stone, it disappears into the water. If the sea is particularly calm, it may be seen that its wings flap rapidly for three or four strokes, then follows a quick short sail, the bird seldom rising more than a foot or two from the surface of the water. Its flight seems to be hurried and in a straight line, coming to an abrupt termination as the bird dips. It is not easy to observe at sea, but its flight is so peculiar that it cannot well be mistaken for any other form of petrel.

GENERAL DISCUSSION OF THE EVOLUTION AND DISTRIBUTION OF THE PELECANOIDIDÆ

The taxonomy of minor groups remains largely a matter of opinion, and, in preparing the foregoing sections of this paper on a little-known family of birds, the writers have regarded the presentation of ordered facts as of greater moment than the construction of a new system of classification. We trust that our descriptive data, based in the main upon large series of specimens, have at least been made communicable; that they may be used and, if necessary, reinterpreted by later workers. If we have succeeded in discovering and recording essential facts of the morphology, life history, and distribution of the birds, the particular systematic rank that we have ascribed to each of the several divisions of the Pelecanoididæ is at best of secondary importance.

We believe, nevertheless, that our classification dividing the single genus of this small family into four subgenera, and one of the latter in turn into two species and five subspecies, is in harmony with the actual conditions of structural and genetic relationship. This does not imply that the various subspecies, species, or subgenera, as the case may be, have precisely equal value, because nature is seldom uniform and conventional. Of the geographical races of *Pelecanoides urinatrix*, for instance, *dacunhæ*, *berard*, and *coppingeri* are clearly more sharply marked

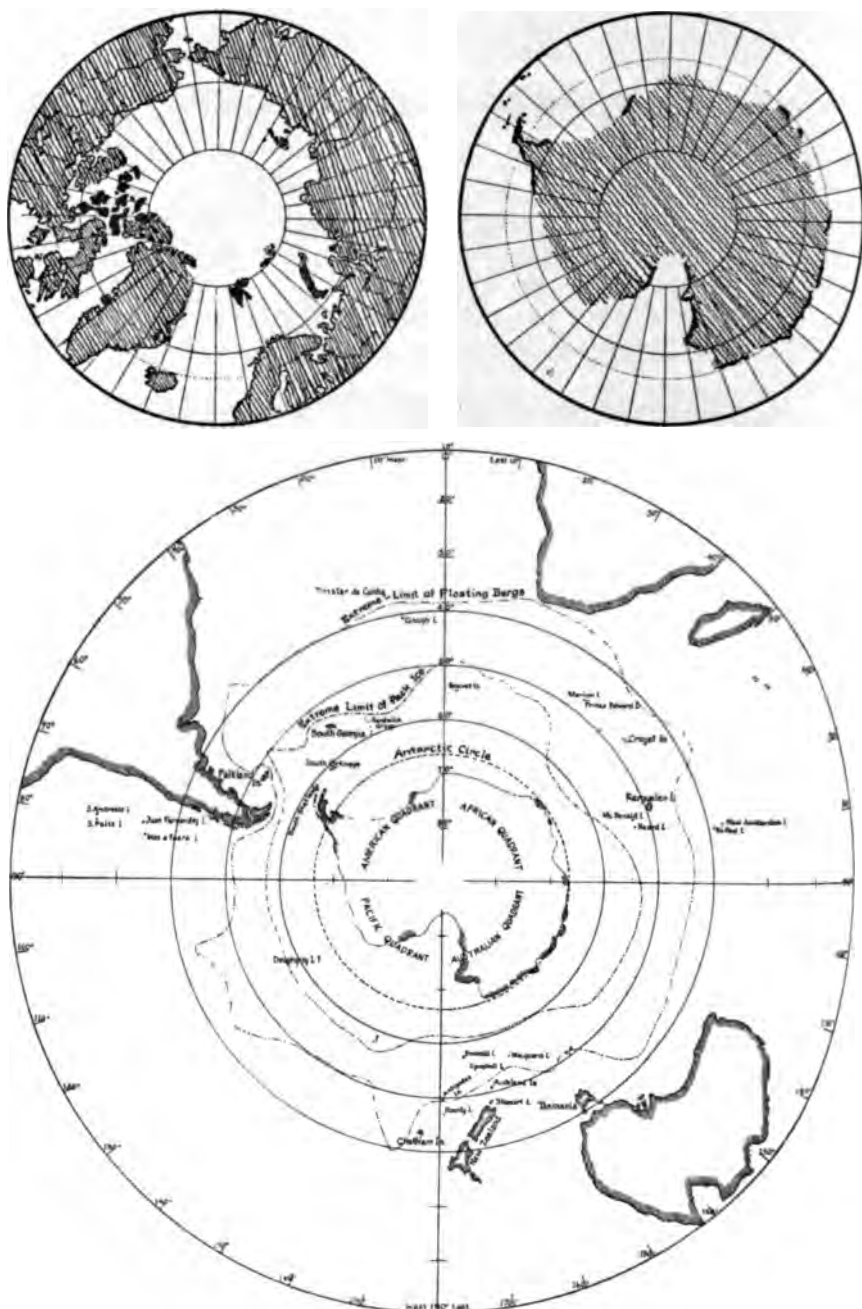


Fig. 6. Sketch maps in polar projection showing the relative distribution of land and water about the poles, the limits of pack and drift ice in the southern hemisphere, and the true geographical relations of the breeding grounds of all forms of Pelecanoidae.

Owing to the notoriously great extension of polar physiography and climate around the southern axis of the world, the conditions of zoological distribution in antarctic and subantarctic regions have been more limiting and inflexible than in the arctic, since at least late Tertiary time. Arctic sea-birds might fly from the shores of one northern continent to those of another directly across the restricted North Polar Sea. Antarctic birds, on the other hand, would be prevented from utilizing correspondingly direct routes by the absolute barrier of the Antarctic Continent, with its high elevation and enormous area. The subantarctic, insular breeding grounds, moreover, are separated by vast stretches of ocean, and the paths of dispersal connecting many of them must, for the reasons stated, have roughly followed arcs of the latitudinal lines rather than the shorter chords. In the case of two antipodal breeding grounds of diving petrels, namely South Georgia and Tasmania, the discrepancy between the transpolar distance and the categorical flight-route along the parallel of latitude amounts to about 1300 statute miles.

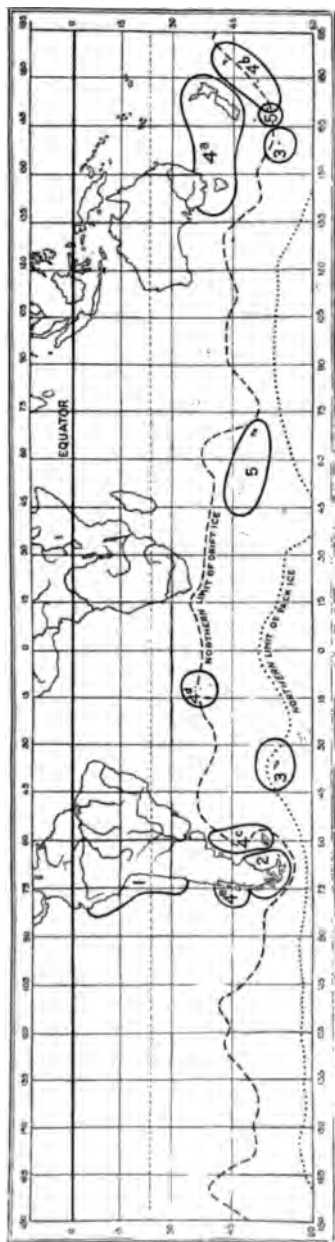


Fig. 7. Distribution of the Pelecanoididae.

Ranges of the five species are denoted by figures: those of the subspecies of *Pelecanoides urinatrix* by letters following the figure 4.

1. *P. garnoti*. Coasts of Peru and Chile.
2. *P. magellani*. Magellanic region and the southerly coasts of Patagonia.
3. *P. georgicus*. South Georgia and Macquarie Island.
- 4a. *P. urinatrix urinatrix*. New Zealand, Tasmania, and the southeastern coast of Australia.
- 4b. *P. urinatrix chinamensis*. Chatham Islands, and southerly outliers of New Zealand (?).
- 4c. *P. urinatrix beardi*. Falkland Islands; northward in migration to the coast of Argentina (?).
- 4d. *P. urinatrix dacotae*. Tristan da Cunha, and Gough Island (?).
- 4e. *P. urinatrix coppiogeri*. Northern parts of the Fuzuan Archipelago of Chile.
5. *P. ezaki*. Kerguelen and Crozet Islands, Auckland Islands.

off from the typical subspecies than is *chathamensis*; and yet none of the former has attained sufficient divergence to raise it to the grade of species. In the case of *dacunhæ*, *berard*, and *coppingeri* we may assume that complete geographic isolation has been an important asset to the evolutionary processes that have so markedly differentiated these three forms from other representatives of the *urinatrix* group, while similarity of the subantarctic life environment has at the same time tended to keep all the races fairly uniform. Of the opposing factors—one centrifugal, the other centripetal—it may be conjectured that the former would ultimately gain the upper hand and fashion full species out of races which may now be considered incipient species.

Figure 7 shows that the circumpolar distribution of the *Pelecanoidæ*, excepting only *P. garnoti*, is confined within a belt bounded by the 35th and 60th parallels of south latitude. Excluding again the range of *garnoti*, practically all the regions inhabited by diving petrels are characterized by tempestuous weather, a high scale of cloudiness, and heavy precipitation. All the habitats, even that of the tropical *garnoti*, are situated in relatively cold oceans in which the annual variation in surface temperature nowhere exceeds 6.6° C. Furthermore, the shores of all the breeding grounds are bathed by effluents of the Antarctic Drift, only slightly tempered, in a few instances, by warm counter currents.

In longitudinal extent the range of the species *Pelecanoides urinatrix*, as may be seen on the map, is practically as great as that of the whole family, but it is proportionately more restricted in its breadth north and south. The known range of *urinatrix* lies, for example, entirely outside of the extreme limit of pack-ice. The mean annual temperature of the atmosphere at the breeding grounds of the geographical races of *urinatrix* varies from 5.5° C. at the Falklands to 10° C. on the coast of Tasmania.

At South Georgia, which lies within the limit of pack-ice, and at Macquarie Island, the meteorological conditions are distinctly more severe than at any of the islands inhabited by *urinatrix*, and the summer temperature is notably lower. The climate is, in some respects, polar rather than subantarctic, the mean annual temperature at South Georgia being below 1.5° C. *Pelecanoides georgicus* is therefore endemic in a more inclement zone than any part of the known range of *P. urinatrix*. In view of this, determination of the status of the diving petrel of Bouvet Island, where a representative will almost certainly be found, and of that of the South Sandwich Islands, where a resident form may be looked for with only slightly less confidence, can not fail to prove of extraordinary interest. In fact, the accompanying map (Fig. 7) seems to show

such a remarkable correlation between the distribution of the diving petrels on the one hand and temperature, latitude, and the geographical limits of floating polar ice on the other, that future discoveries at islands not yet ornithologically investigated may serve to put this apparent correlation to a conclusive test. If resident diving petrels occur at some of the unknown or little-known subantarctic islands and if our present ideas upon the distribution of the group are substantially correct, the affinities of the unknown birds at the respective islands should prove to be specifically as follows:

Gough, Amsterdam, St. Paul, Bounty, and possibly Antipodes Islands. *P. urinatrix*.

Prince Edward and Marion Islands. *P. exsul*.

Campbell, Emerald, McDonald, Heard, Lindsay (or Bouvet), South Sandwich, and Dougherty Islands. *P. georgicus*.

It is at least gratifying to feel that an hypothesis of geographical distribution may be empirically confirmed or eliminated.

The only alternative to accepting the theory of an isothermal type of distribution of the insular, subantarctic diving petrels, as now known, is to assume that the resident birds of such widely separated localities as South Georgia and Macquarie Island, for instance, are products of convergent evolution—that the action of similar environments has nipped in the bud every differential tendency and has produced homoplastic counterparts which, on morphological grounds, cannot be separated even subspecifically!

However important climatic factors may be, the complex of influences controlling the present distribution of most forms of diving petrels is by no means fully understood. What sort of external limitation or competitive interaction, for instance, keeps apart the adjacent Fuegian and Falkland birds? The determinants of the aberrant range of *Pelecanoides garnoti*, on the other hand, are more readily comprehensible than those of any of the other species. The cold Humboldt Current, which flows northward and laves the west coast of South America to within a few degrees of the equator, combines with other natural features, such as the Andean barrier and the prevailing southwesterly winds, to maintain more regular and favorable oceanic and meteorological conditions than are to be found along any similar continental shore. For a thousand nautical miles on the Peruvian seacoast the surface temperature of the ocean water changes scarcely at all, nor is the variation according to hour, day, or month, significant. At the Chincha Islands, the extremes of annual variation are not more than 1.3° C

apart.¹ Evaporation is slight, and the proximity of cold sea-water and heated land makes condensation and precipitation of moisture virtually impossible. The chilled, viscous water absorbs oxygen freely, which, in combination with the clear sunlight, supports an abundant growth of algæ. The latter in turn furnish subsistence to the teeming plankton and nekton fauna upon which the diving petrels feed. The extraordinary circumstance of a subantarctic current, with its exhaustless resources of uniform food supply, washing equatorial continental shores, accounts beyond a doubt for the distribution of *Pelecanoides garnoti*, as well as of the penguin, *Spheniscus humboldti*, northward into the heart of the tropics. Where the Humboldt Current meets a warm, southward-flowing current—El Niño—at a point varying between 3° and 7° 30' south latitude, the warmer, lighter stream overflows the colder, and the northward extension of the diving petrel is abruptly checked.

The same general conditions also partly explain the characteristics, physiological as well as structural, which differentiate *P. garnoti* from its congeners. Alone of all the family, it inhabits a mild region of rainless, relatively placid seas with their invariable surplus of accessible food. The factors which inhibit increase of size in the more southerly species are apparently not effective, and this largest and most northerly of diving petrels has, moreover, overcome the limitations of a fixed breeding season—a system which is so rigidly imposed upon all the subantarctic forms—and has assumed the continuous breeding custom common to many tropical sea-birds. Throughout the whole family, there is an obvious tendency toward decrease in size with decrease in temperature of the habitat.

The insular species of diving petrels, including *georgicus*, *exsul*, and the races of *urinatrix*, appear to make migrations of considerable extent, or at least to lead truly pelagic lives during part of the year. In the systematic accounts we have cited records of these birds at points far from land in the South Atlantic, Indian, and Pacific oceans. The continental species, *garnoti* and *magellani*, on the other hand, would seem to be strictly littoral. Neither form has been recorded from any offshore locality; *P. magellani* has not invaded the territory of its neighbor, *P. u. berard*; *P. garnoti* is unknown at Juan Fernandez.² Further evidence of the permanent residence of these two species within

¹Coker, R. E., 1918, Geographical Review, February, pp. 127-135.

²A map showing the distribution of the Pelecanoididae in the Atlas of Zoogeography (Bartholomew's Physical Atlas, V, 1911), Plate xvii, Map 5, is misleading in that the range of these birds is carried entirely across the Pacific Ocean. There is yet no evidence that diving petrels occur in any part of the Pacific between the littoral waters of South America and the New Zealand region. Certainly in the case of *Pelecanoides garnoti* the area of distribution and the breeding range appear to have the same limits; both seem to be confined within the scope of the cold Humboldt Current.

the environs of their actual breeding ranges is to be found in their notably uniform plumages (cf. p. 526), a condition contrasting strongly with the wide amplitude of individual variation in *P. georgicus*, for instance. This is in accord with the recognized truth that, other factors being equal, so-called stationary species exhibit a lesser degree of individual variation than species which undertake long periodic migrations.

Mathews advances the opinion that the great age of the family of diving petrels, as an offshoot from some more generalized tubinarine stem, is indicated by the fact that the nostrils of even nestlings point directly upward and show no trace of the horizontal tubes such as are common to all other birds of the order. Upon a similar criterion we may judge that the parting of the ways of the four subgenera within the single genus is also of ancient standing, because the bills of very young specimens show as well as those of adults the diagnostic differences in the structure of the nasal orifices and the form of the mandibular rami.

In the complete absence of a fossil record, and of knowledge of a secular alteration of antarctic climate during the Tertiary, we can perhaps draw no sure conclusions regarding the origin and dispersal of the Pelecanoididæ. Nevertheless, the line of reasoning which W. D. Matthew¹ has so successfully used to explain the distribution of various higher groups of vertebrates from holarctic centers is applicable in a very interesting way to this small family of birds. All the known subgenera and species of diving petrels except *P. exsul* are indigenous within a distance of twelve hundred miles of the southern extremity of South America. It would seem, therefore, that those agencies which have been governing the course of evolution within the family have been most active in the region referred to, and that the point of original dispersal is, indeed, not far from Cape Horn. In this locality we find to-day *Pelcanoides magellani*, the most strongly marked and distinctive of all diving petrels, and in this sense the most advanced member of the genus. The Fuegian species represents, as it were, the latest wave in the flood of evolutionary progression rising from the contiguous cradle of the race, which is never the locality where a *primitive* member is to be sought. The more distant *Pelecanoides garnoti* has, except for its increase in size, differentiated much less from the family type. Still more distant and isolated diving petrels, such as *Pelecanoides georgicus* and the antipodal races of *P. urinatrix* (e.g., *P. u. chathamensis*) share with one another strong superficial resemblances of color and pattern, small size, etc., which are due, we assume, not to close relationship, nor to homo-

¹Matthew, W. D. 1915. 'Climate and Evolution,' Ann. N. Y. Acad. Sci., XXIV.

plasy, but rather to the retention among these conservative forms of primitive, nonadaptive characters. The species of diving petrels confined exclusively to the New World (*magellani*, *garnoti*) occupy, as has been shown, a wide range in environments, biotic as well as physical, extending from the arid coast of northern Peru to the islets of Cape Horn; but the species *urinatrix*, *exsul*, and *georgicus*, which, according to the hypothesis here advanced, began their invasion of the Eastern Hemisphere from the Falkland Islands, have found a series of equable habitats in a subantarctic belt of the southern oceans. Because of the relatively uniform, even if cloudy and blustery, environment throughout their range, they have thus far radiated, if at all, only to the extent of forming variants worthy of the rank of subspecies. Peripheral representatives of *urinatrix* and *georgicus*, particularly the subspecies of the New Zealand region, are probably most like the ancestral type of diving petrel; and they now exist exactly where we should expect to find them, viz., as far as possible from their point of origin.

The principal desiderata for further study of this interesting group are as follows:

1. Skeletons of the five species.
2. Downy young of *Pelecanoides magellani*, so that it may be determined whether the neossoptyles of this species resemble in color those of *P. garnoti*, *P. georgicus*, or of neither.
3. A study of representative series of specimens from the Australian and New Zealand habitats, especially from the southern outliers of New Zealand. As regards the diving petrels known to inhabit the Auckland, Antipodes, and Campbell Islands, there has yet been advanced little or no information of critical value.
4. A search for breeding representatives at the South Sandwich group, Lindsay (or Bouvet) Island, Marion and Prince Edward Islands, Heard and McDonald Islands, and the South Pacific islets of Nimrod and Dougherty, if the last two exist, which now seems doubtful.¹

PLATE XX

Homoplasy in sea-birds of two orders and two hemispheres. The skins at the right and left ends of the series are subantarctic diving petrels (*Pelecanoides magellani*); the two central skins are boreal auklets (*Alle alle*). Cf. pp. 516 and 530.



PLATE XXI

Fig. 1. Nestlings of *Pelecanoides garnoti* (Brewster-Sanford Collection 1164, 1165) taken at San Gallan Island, Peru July 3, 1913. The two downy plumages of this species differ markedly in color from the corresponding plumages of *P. urinator* and *P. georgicus* (Cf. text-fig. 4, p. 524).

Fig. 2. Progressive wear of the plumage in adult males of *Pelecanoides magellani*. At the left, bird in entirely new plumage taken in the Strait of Magellan, August 1, shortly after the completion of the annual molt. In the center, bird from Reynon Island, Chile, December 21, showing the effects of wear which has nearly obliterated the white edgings of the feathers on the back. At the right, bird with the white edgings entirely effaced, taken at Punta Arenas, Argentina, on March 6, or shortly before the inception of the annual molt.

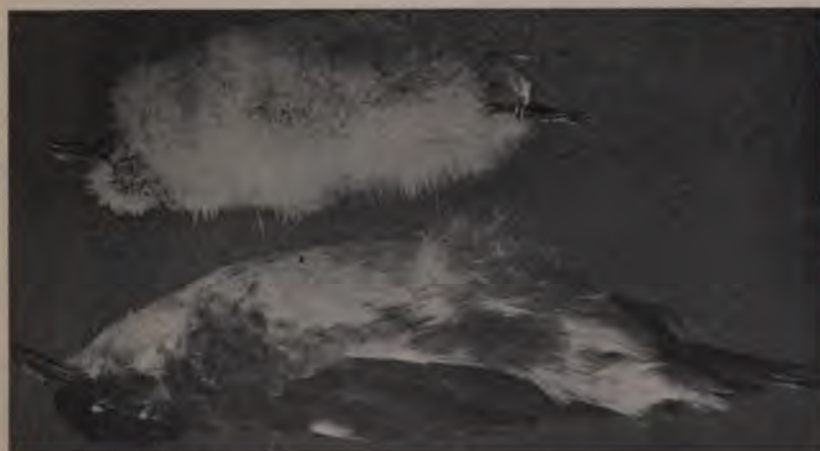


Figure 1



Figure 2

PLATE XXII

Fig. 1. From left to right, mature males of *Pelecanoides garnoti*, *P. magellani*, and *P. georgicus*.

Fig. 2. Structural differences of subgeneric value shown in a ventral view of the bills of four breeding specimens of diving petrels. At the left, two males of *Pelecanoides urinatrix berard* (subgenus *Pelecanoides*), Falkland Islands, November 1915; at the right, one male and one female of *Pelecanoides georgicus* (subgenus *Pelagodyptes*), South Georgia, January 1913.



Figure 1



Figure 2

PLATE XXIII

Fig. 1. *Pelecanoides georgicus*. Photograph from life of a bird which flew on board a vessel in Possession Bay, South Georgia, March 13, 1913.

Fig. 2. Individual variation in the extent of mottling on the jugulum, illustrated by two breeding females of *Pelecanoides georgicus* collected at Cumberland Bay, South Georgia, in December 1914.



Figure 1

+



Figure 2

PLATE XXIV

Fig. 1. *Pelecanoides garnoti* and its egg, after the opening of a burrow on San Gallan Island, Peru, July 4, 1913.

Fig. 2. *Pelecanoides urinatrix berard*, after the opening of its nest-burrow on Kidney Island, Falkland Islands, November 6, 1915.

Both photographs by Rollo H. Beck.



Figure 1



Figure 2

Article XVIII.—THE HERPETOLOGY OF NAVASSA ISLAND

BY KARL PATTERSON SCHMIDT

PLATES XXV AND XXVI

The small island of Navassa is situated about one-third the distance between the southern peninsula of Haiti and Jamaica. Its topography recalls that of Mona Island, in the passage between Santo Domingo and Porto Rico, at least in its sheer sea cliff. It differs from Mona Island chiefly in the fact that there is a broad terrace at the top of the sea cliff, with a rising mound in the center, while the slightly undulating surface of Mona appears quite flat from a distance. Like Mona, the island is arid, and the vegetation scanty. The "phosphate" deposits on Navassa were found in surface pockets, which, after the removal of the phosphate, make travel on the surface of the island extremely difficult and dangerous. The origin of these surface deposits offers a difficult problem. It is possible that the roofs of caves in which bat guano accumulated have been eroded away, leaving the cave floors as the present land surface. The surface rock is as rough as that of Mona, or the "diente perro" country of Cuba described by Barbour (1914, p. 308).

For the above brief description and the accompanying photographs I am indebted to Mr. Frederick C. Hingsburg, under whose direction the Navassa Island lighthouse was built.

The herpetology of Navassa Island has been very imperfectly known. The Beck collection, on which the present account is based, increases the number of species of reptiles recorded from Navassa Island from five to thirteen.

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1919. BARBOUR, THOMAS. 'A New Rock Iguana from Porto Rico.' Proc. Biol. Soc. Wash., XXXII, pp. 145-148. (Lists *Cyclura nigerrima* from the original records).
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ANNOTATED LIST OF REPTILES OF NAVASSA ISLAND

1. *Sphaerodactylus cinereus* MacLeay

A Cuban and Hispaniolan species, recorded for the first time from Navassa Island, in the R. H. Beck collection.

2. *Sphaerodactylus becki* Schmidt

Related to *S. scaber* in Cuba and *S. picturatus* in Haiti.

3. *Anolis semilineatus* Cope

A single specimen, referred to *A. olssoni* in my description of that species. Additional specimens of this form might prove to be distinct from the Hispaniolan species, and it seems preferable to record it provisionally as *A. semilineatus*.

4. *Anolis distichus* Cope

A single specimen in the R. H. Beck collection adds this species to the fauna of Navassa Island.

5. *Anolis longiceps* Schmidt

A remarkable species in the extreme acumination of the snout, apparently related to the Cuban *Anolis porcatus* through *Anolis maynardi* Garman from Little Cayman Island.

6. *Anolis latirostris* Schmidt

This species represents the opposite extreme, in the shape of its snout, from *A. longiceps*. It is not closely related to any of the Greater Antillean anoles.

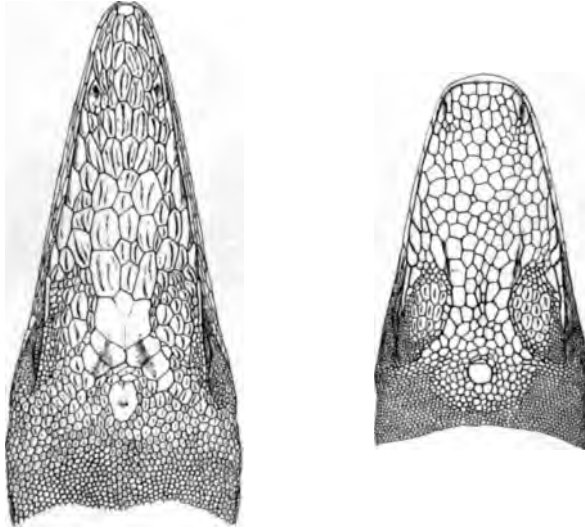


Fig. 1. *Anolis longiceps* Schmidt. Type (A. M. N. H. No. 12597). Three times natural size.

Fig. 2. *Anolis latirostris* Schmidt. Type (A. M. N. H. No. 12598). Three times natural size.

7. *Chamaelinorops barbouri* Schmidt

(Figs. 3 and 4)

The occurrence of this remarkable lizard on the small island of Navassa may be regarded as a case of relict distribution, the Navassa species being the surviving remnant of a more widely distributed form.

8. *Leloecephalus eremitus* Cope

(Figure 5)

In coloration this species is closely allied to *L. personatus* Cope from Hispaniola, but in the larger number of anterior head scales it is quite distinct from other West Indian species of the genus.

9. *Cyclura nigerrima* Cope

Recorded and figured by Barbour and Noble, 1916, p. 162, Pls. XI and XV, figs. 1 and 2.

10. *Celestus badius* Cope

The Beck collection contains a single small specimen of this species, unfortunately insufficient to settle the status of the Navassa form.

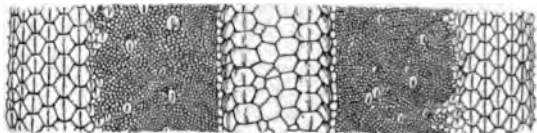
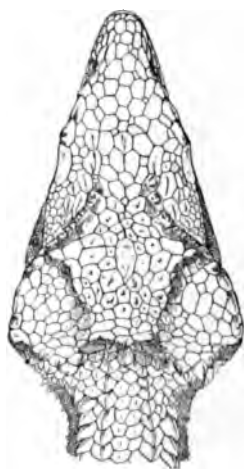


Fig. 3. *Chamaelinorops barbouri* Schmidt. Type (A. M. N. H. No. 12603). Three times natural size.

Fig. 4. *Chamaelinorops barbouri* Schmidt. Type (A. M. N. H. No. 12603). Scales around the body midway between the front and hind limbs. Three times natural size.

11. *Ameiva navassa* Schmidt

This handsomely colored *Ameiva* appears to be related to *Ameiva auberi* of Cuba, more closely than to the Hispaniolan species.

12. *Typhlops sulcatus* Cope

Probably referable to *Typhlops lumbricalis* (Linnæus) but I have retained Cope's name pending a verification of the status of the Hispaniolan form.

13. *Tropidophis bucculenta* (Cope)

The only specimen of *Tropidophis* recorded from Navassa was described by Cope as a subspecies of *maculata*. I have retained the species as distinct partly because the status of the Hispaniolan *maculata* is unsettled, partly because of the high degree of peculiarity of the Navassa fauna.

The fauna of Navassa Island is a considerably larger one than would be expected from the size of the island and from analogy with Mona Island. It does not appear to be by any means exhausted. A species of *Eleutherodactylus* and a skink should certainly be found there and probably one or two additional species of snakes.

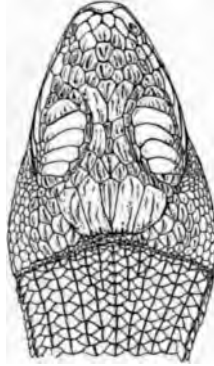


Fig. 5. *Leiocephalus eremitus* Cope. (A. M. N. H. No. 16919). Three times natural size

Several of the species are still imperfectly known, and inferences as to the relations of the fauna are consequently uncertain. Taken in a broad sense, however, the relations with the surrounding islands are about as follows

Species related to or identical with Jamaican forms.....3.

(*Celestus badius*, *Typhlops sulcatus*, *Tropidophis bucculenta*).

Species related to or identical with Cuban forms.....7.

(*Sphaerodactylus cinereus*, *S. becki*, *Anolis longiceps*, *Chamaelinorops barbouri*, *Ameiva navassæ*, *Typhlops sulcatus*, *Tropidophis bucculenta*).

Species related to or identical with Hispaniolan forms.....10.

(*Sphaerodactylus cinereus*, *S. becki*, *Anolis semilineatus*, *A. distichus*, *Leiocephalus eremitus*, *Cyclura nigerrima*, *Celestus badius*, *Ameiva navassæ*, *Typhlops sulcatus*, *Tropidophis bucculenta*).

PLATE XXV

Fig. 1. Navassa Island from the sea.

Fig. 2. Schooner unloading cargo.

Fig. 3. The surface of the terrace.

(Photos by Mr. Frederick C. Hingsburg)



PLATE XXVI

- Fig. 1.** The rocky coast of Navassa.
Fig. 2. The Navassa Lighthouse under construction.
Fig. 3 The completed lighthouse, showing the rocky surface and vegetation of the highest part of the island.

(Photos by Mr. Frederick C. Hingsburg)



**Article XIX.—REPTILIAN AND STEGOCEPHALIAN REMAINS
FROM THE TRIASSIC OF PENNSYLVANIA IN THE
COPE COLLECTION**

BY F. VON HUENE, Tübingen

The whole Triassic Cope Collection has been sent over to me for reëxamination from The American Museum of Natural History in New York City. Therefore my hearty thanks are due to Professor H. F. Osborn and Dr. W. D. Matthew. The collection consists of New Mexican and Pennsylvanian fossils. In a previous paper¹ I gave some observations on the New Mexican part of that collection and now the Pennsylvanian fossils are to be briefly treated.

The most important part of the Pennsylvanian Triassic collection consists of nicely preserved teeth which have been described and named, but not all of them have been figured, and some have been figured in rather rare papers. Therefore some doubts have existed about what these teeth are like and as to their classification. It is necessary to have good figures of these types, although no interesting conclusions are to be made from them. Only after this has been done can they be identified with skulls and skeletons more completely preserved. Most of them belong with the *Parasuchia*, and since the paper of McGregor (1906) have been considered as synonymous with *Rutiodon carolinensis*. In addition to these teeth the collection contains the bones of "*Belodon*" *lepturus*, also considered as synonymous with *Rutiodon carolinensis* by McGregor. With the parasuchian remains there are a few saurischian teeth, also some stegocephalian and possibly pterosaurian bones.

I. PARASUCHIA

***Palæoctonus appalachianus* Cope**

Figures 1 and 2

The teeth indicate an enormous parasuchian skull, possibly something like *Machæroprosopus validus* Mehl.² There are posterior and anterior teeth. Cope has figured one of each kind. The posterior tooth is compressed and relatively short and broad, with sharp and finely serrated longitudinal edges. The medial side of the tooth is nearly flat, the lateral side more rounded. The anterior edge is nearly straight, the posterior more curved, so that the top of the tooth points a little

¹1915, Bull. Amer. Mus. Nat. Hist., XXXV, pp. 485-507.

²1916, Quart. Bull. Univ. Oklahoma, N. S. 103, March, p. 6.

more to the anterior direction. The whole tooth is very slightly curved in transverse direction (little convex laterally and little concave medially). As all illustrations of the teeth are given in natural size or $\times 2$, I do not think it necessary to give measurements.

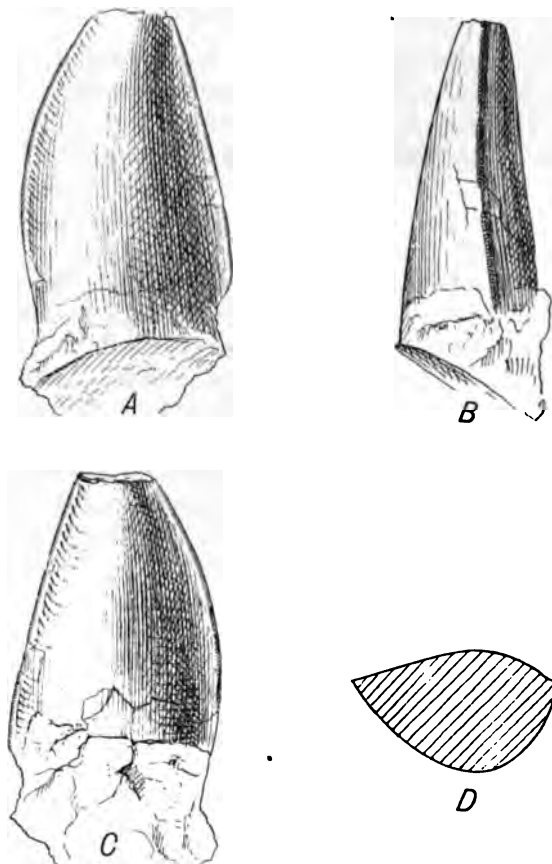


Fig. 1. *Palaeoctonus appalachianus* Cope (No. 2320). Natural size. Posterior tooth. Three aspects: lateral (A); anterior (B); medial (C); with section (D).

The anterior tooth (Fig. 2) is very much higher and less compressed; viewed from outside it looks nearly round, only the medial side is nearly flat. The latter is bordered by two longitudinal edges with the same serration as in the posterior tooth, only the edges are not so sharp as in the posterior tooth. The top of this tooth is very acutely pointed; this

is also true in another specimen. The transverse curvature is rather more than in the posterior tooth, but is only very slight in the second specimen.

The teeth figured by Cope have the number 2320, and the other two 2329.

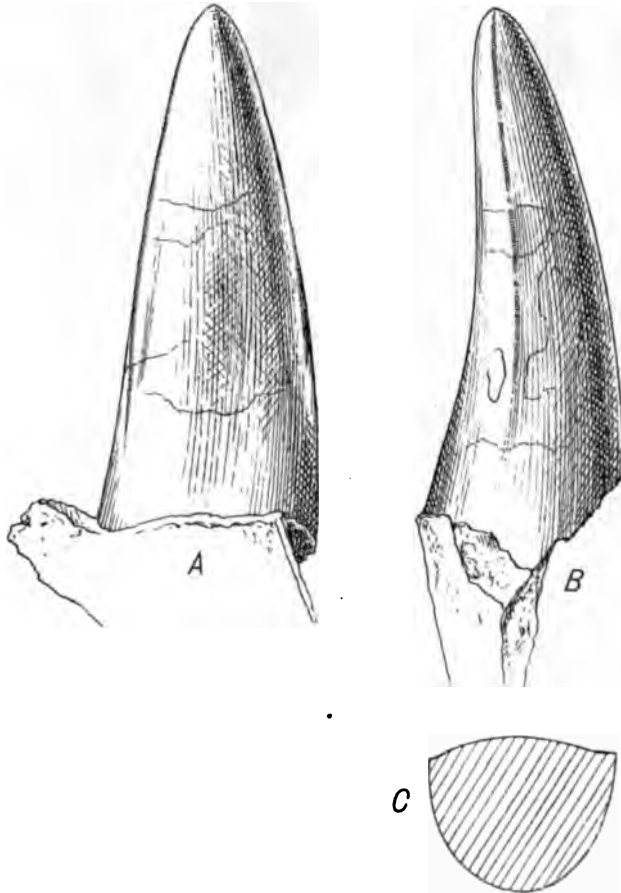


Fig. 2. *Palaeoctonus appalachianus* Cope (No. 2337). Natural size. Anterior tooth. Anterior (B) and lateral (A) aspects, with section (C).

***Palaeoctonus aulacodus* Cope**

Figures 3 and 4

These teeth have also been described as *Suchoprion aulacodus* by Cope. They are smaller than *P. appalachianus* and relatively thicker, but are also somewhat compressed. The difference between the flat

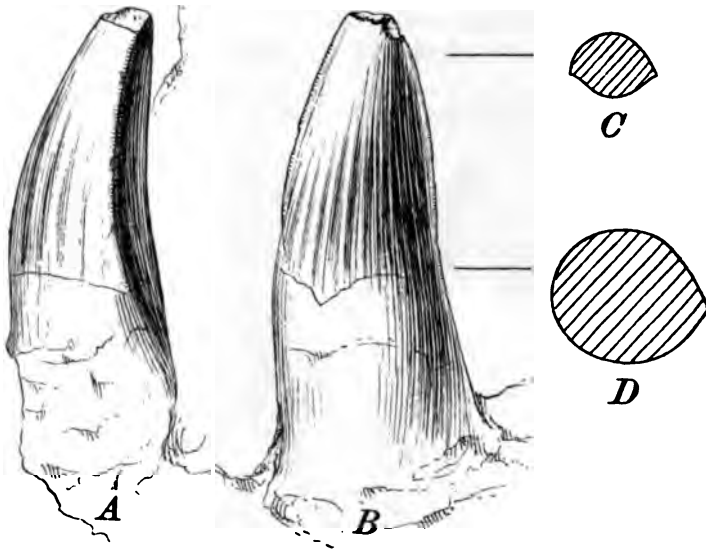


Fig 3. *Palzortonus aulacodus* Cope (No. 2335). $\times 2$. Anterior (A) and lateral (B) aspects, with sections (C, D).

medial and the much rounded lateral side is great. Both longitudinal edges are finely serrated. The posterior edge is shorter than the anterior, especially in the smaller of the two teeth; the anterior edge runs the full length of the crown. The smaller of these teeth shows very slight indications of longitudinal ridges in the lower part of the lateral face. In the figure they are perhaps a little too strong. The transverse curvature is rather well shown in both teeth.

***Suchoprion sulcidens* Cope**

Figure 5

There is only a single tooth mentioned by Cope with this name, but never described or figured. This tooth is nearly round in horizontal section. It is especially characterized by the longitudinal ridges in the middle and lower part. In the upper half are two slight longitudinal edges, one of them with very minute serration, the other without serration, but the top of the tooth is broken and might have been serrated in the uppermost part. The tooth possesses a well-marked transverse curvature and resembles the teeth of *Mystriosuchus planirostris* of Württemberg.

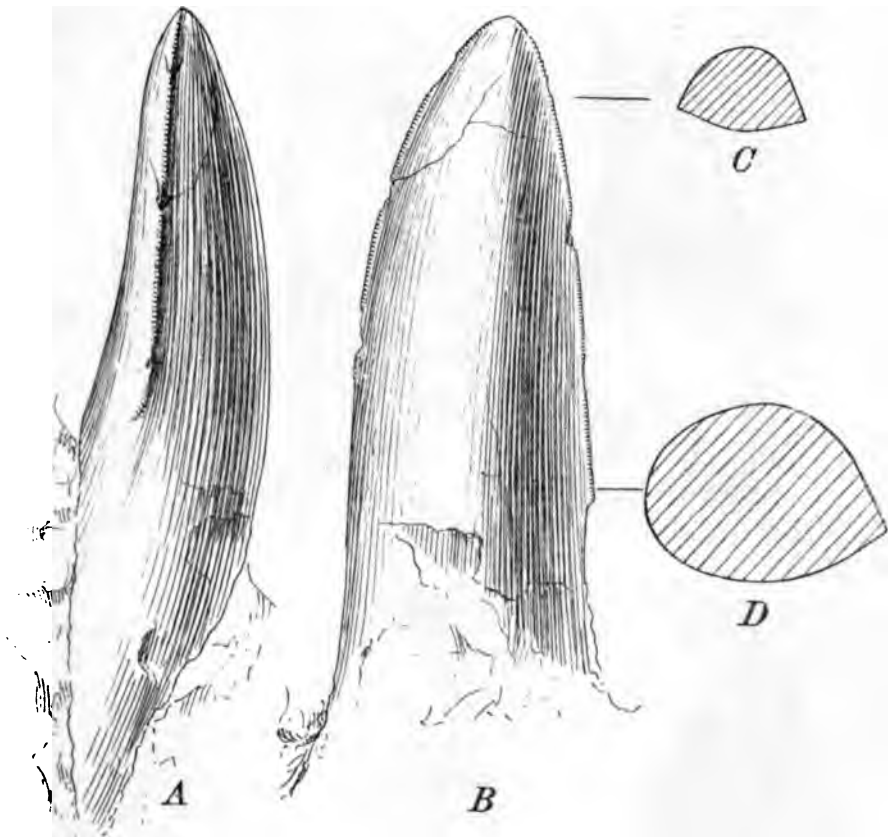


Fig. 4. *Palaeorion aularodus* Cope (No. 2335). $\times 2$. Anterior (A) and lateral (B) aspects, with sections (C, D).

***Suchoprion cyphodon* Cope**

Figure 6

There are a few teeth of this type. They are round in horizontal section and are nicely curved in transverse direction. Two longitudinal edges border the narrower medial side. These edges consist of extremely minute and short serrations.

***Clepsysaurus pennsylvanicus* Cope**

Figure 7

Of *Clepsysaurus pennsylvanicus* there is the type specimen of Cope and Dana, marked with number 2337. It is an acute, slender tooth, round in section, but rather thicker than broad. It has a very slight

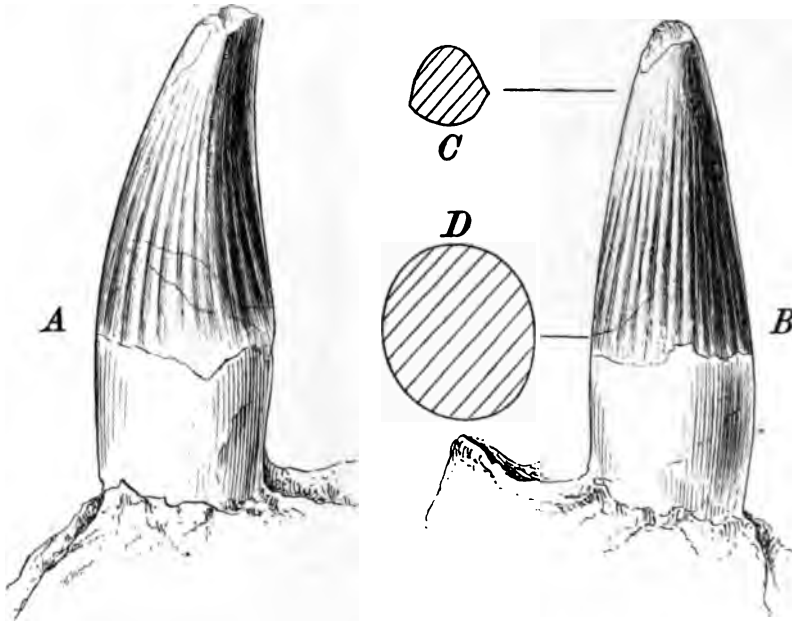


Fig. 5. *Suchoprion sulcidens* Cope. $\times 2$. Anterior (A) and lateral (B) aspects, with sections (C, D).

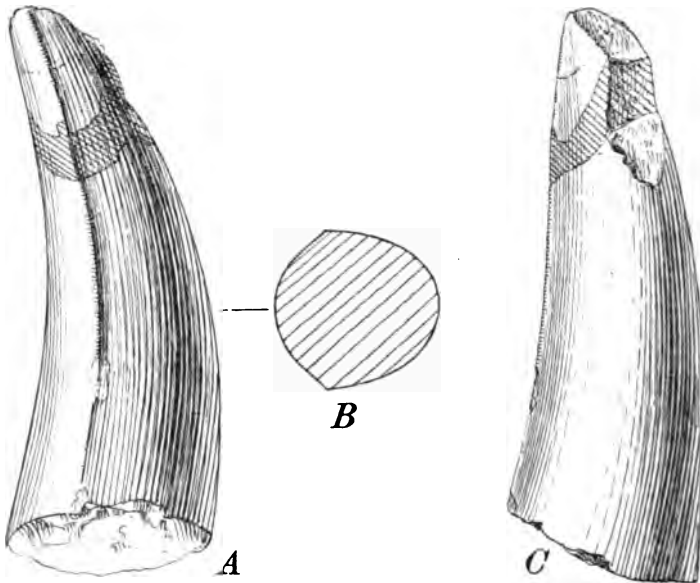


Fig. 6. *Suchoprion cyphodon* Cope (No. 2331). $\times 2$. Posterior (A) and lateral (C) aspects, with section (B).

double curvature in transverse direction and possesses two longitudinal edges without any serration, just cutting. They are both as long as the preserved part of the tooth, which is practically the complete crown.

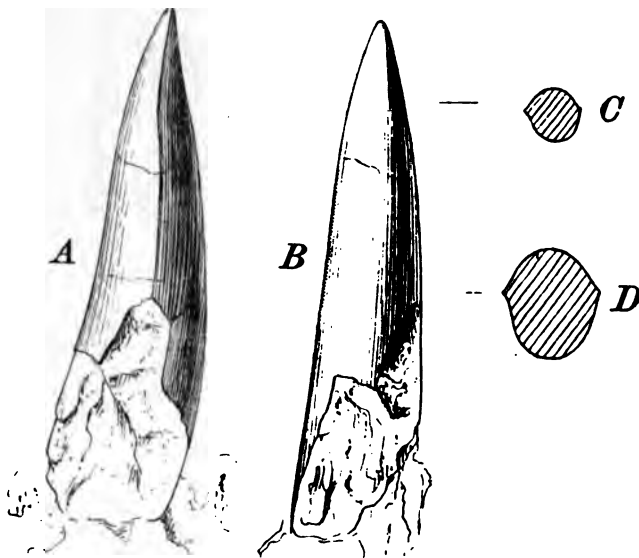


Fig 7. *Clepsysaurus pennsylvanicus* Cope (No. 2337). $\times 2$. Two aspects (A, B), with sections (C, D).

***Clepsysaurus veatleianus* Cope**

Figures 8 and 9

The tooth representing this species has not previously been figured. It is nearly straight, slightly compressed and has only one sharp longitudinal edge with well-marked but minute serrations.

It is probable that another tooth (Fig. 9) associated in the collection with *Suchoprion cyphodon* belongs to *Clepsysaurus veatleianus*. It is larger than the type specimen. The upper half of it is broken off. This tooth is also slightly compressed, has one cutting serrated edge; the opposite side is rounded. The tooth is curved not in transverse but in sagittal direction.

"Palæosaurus" fraserianus Cope

Figure 10

The tooth to which Cope gave this name resembles very much the former species, but it is a good deal smaller. It has only one cutting edge with minute serration, and the opposite side rounded and rather

thick. It is curved in sagittal direction as in the former species. I suppose that the teeth of *Clepsysaurus vealleianus* and *Palæosaurus fraserianus* represent the same species, and as the former name was given a year earlier the second should disappear, if this conclusion be true.

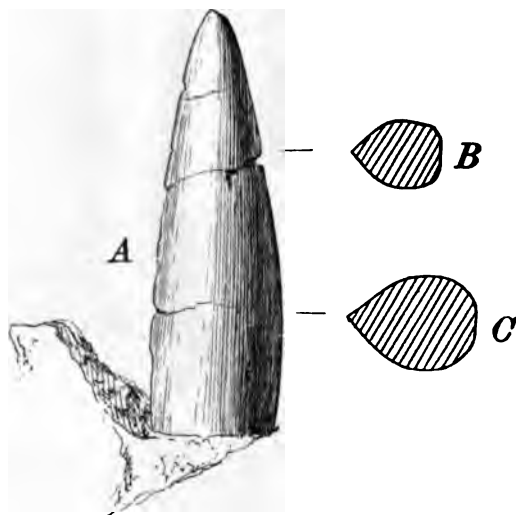


Fig. 8. *Clepsysaurus vealleianus* Cope (No. 2330). Natural size. Lateral aspect (A), with sections (B, C).

"Belodon" priscus Cope

Figure 11

This tooth is scarcely distinct from the preceding one, except that it is much less curved and the fine serration at the cutting posterior edge is restricted to the upper half; it probably belongs, however, to the same species.

REMARKS ON THE DIFFERENT SPECIES OF THE ABOVE-MENTIONED PARASUCHIAN TEETH

Possibly to a single or more probably to two species of long and low-snouted parasuchians belong Cope's following types of teeth:

Perhaps not belonging with following teeth	{	<i>Suchoprion cyphodon</i>
		<i>Clepsysaurus pennsylvanicus</i>
		" <i>vealleianus</i>
		" <i>Palæosaurus</i> " <i>fraserianus</i>
		" <i>Belodon</i> " <i>priscus</i>

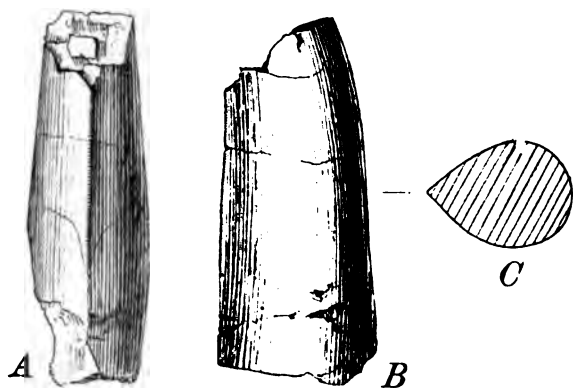


Fig. 9. *Clepsysaurus scalleianus* Cope (No. 2331). $\times 2$. Posterior (A) and lateral (B) aspects, with section (C).

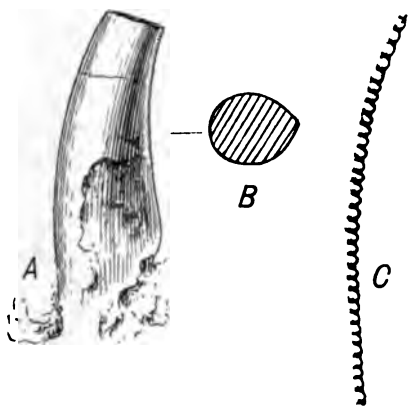


Fig. 10. "*Palzosaurosaurus*" *fraserianus* Cope. Lateral aspect (A), with section (B). $\times 2$. C, serration. $\times 6$.

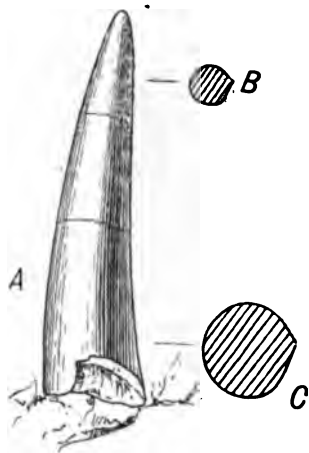


Fig. 11. "*Brilodon*" *priscus* Cope. $\times 2$. Lateral aspect (A), with sections (B, C).

The teeth named *Palæoconus appalachianus* and *P. aulacodus* may belong with a single or with two different species; it is impossible to say. But it is nearly certain that they do not belong with the foregoing named teeth, surely not with the last two. Only American investigators will now be able to decide which of those teeth belong with the recently described genera *Machæroprosopus*, *Angistorhinus*, and *Palæorhinus*, or with *Rutiodon*.

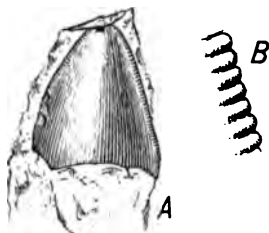


Fig. 12. *Rutiodon carolinensis* Cope (No. 2338). Posterior tooth. A, lateral aspect. $\times 2$. B, serration. $\times 6$.

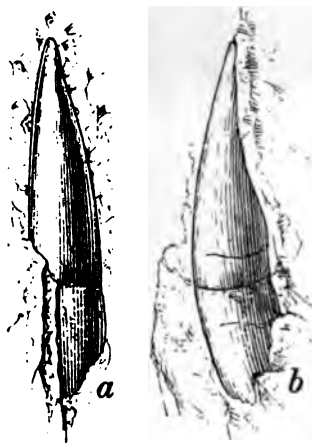


Fig. 13. *Rutiodon carolinensis* Cope (No. 2338). Middle tooth. $\times 2$. A, lateral, B, anterior aspect.

In the same collection there are also four teeth of "*Palæosaurus*" *carolinensis* Cope (No. 2338) with the remark on the label "common" (Figs. 12, 13). They are lying in black bituminous shales of the Deep River coalfield in North Carolina, the same shales as in the Phoenixville tunnel, Pa., which yielded *Rutiodon carolinensis* and "*Belodon*" *lepturus*. Most probably these teeth are those of *Rutiodon carolinensis* and to this probably also belong "*Palæosaurus*" *fraserianus* and "*Belodon*" *priscus*.

Two of these teeth of "*Palæosaurus*" *carolinensis* are of the slender type, one of them has a cutting edge, and two of them are short, broad, flattened and with two cutting edges. That means that the last ones are from the posterior part of the jaws and the first ones from the middle or anterior part.

All of these teeth described under eight names possibly belong with only three or four species:

- I. *Palæoctonus appalachianus* Cope 1877
" *aulacodus*
- II. *Clepsysaurus pennsylvanicus* Lea 1852
" *vealleianus*
Suchopriion cyphodon
- III. "*Palæosaurus*" = *Rutiodon carolinensis* Emmons 1856
" *fraserianus*
"*Belodon*" *priscus*

It is not quite impossible that the teeth under II might belong with *Rutiodon manhattanensis* Huene, and with the fragmentary scapula from Connecticut called by Marsh "*Belodon*" *validus*.

Note on "*Belodon*" *lepturus* Cope.

The type material of "*Belodon*" *lepturus* in black bituminous shales from the Phoenixville tunnel, Pa., forms part of the Cope collection (No. 3879). Cope has given very good figures of these specimens. There are a number of vertebræ, ribs, one femur, a fibula and dermal plates. I do not find any difference from *Rutiodon carlinensis*.

II. SAURISCHIA

Thecodontosaurus gibbidens Cope

Figures 14 and 15

There are two small teeth of the same type as those of *Thecodontosaurus antiquus* Morris, *T. elizæ* Sauvage, "*Plateosaurus*" *ornatus* Huene, and "*Plateosaurus* sp." from Friedrichstrasse near Hechingen (1915, N. Jahrb. f. Min., etc., I, p. 13). They belong



Fig. 15. *Thecodontosaurus gibbidens* Cope. Lateral aspect. $\times 1$.

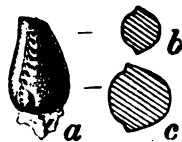


Fig. 14. *Thecodontosaurus gibbidens* Cope (No. 2339). $\times 2$. Anterior aspect (A), with sections (B, C).

to the allophagous division of the Pachypodosauria (Huene, 1914, Centralbl. f. Min., etc., pp. 154-158). These teeth are short and very thick, with a characteristic kind of cutting edges ("Spitzkerbung," as called by the author). The axis of these teeth is slightly curved to the inside, but not at all backwards. There is also a slight resemblance of these teeth to those of *Scelidosaurus*.

III. **STEGOCEPHALIA****?Eupelor durus** Cope

Figures 16 to 18

There is one tooth, fragments of sculptured parts of the skull roof, a good lateral dermal plate, and part of an interclavicular plate of a big labyrinthodont-like *Mastodonsaurus* from the Triassic of Pennsylvania. The tooth (Fig. 16) is straight and conical; its lower part has longitudinal ridges. The parts of sculptured skull bones do not show any suture. All of these fragments are small. The lateral or clavicular plate (Fig. 18) is nearly complete, only the narrow process below the sculptured part of it is fragmentary. The sculpture of these bones is much like that of *Mastodonsaurus*. The aspect of the interclavicular plate (Fig. 17) seems a little different from the sculpture of the clavicular plate; therefore it is not certain they belong to the same species.

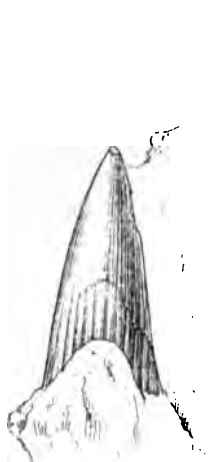


Fig. 16. Labyrinthodont tooth (? *Eupelor durus* Cope) (No. 2333).
× 2.

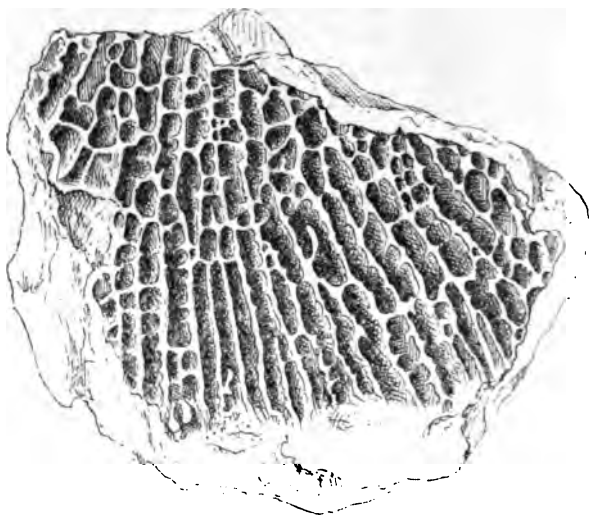


Fig. 17. Part of labyrinthodont inter-clavicular plate (No. 2338).
× 1/2.

IV. **PTEROSAURIA?**

Figures 19 and 20

The probable pterosaurian remains described by Cope as *Rabdopelix longispinis* from the Triassic of Gwynned, Montgomery Co., Pa., have not been found in the Cope collection, but there are two tiny bones in black bituminous shales from the Phoenixville tunnel, Pa. They are in the same black shales which have yielded "*Belodon*" *lepturus* Cope.

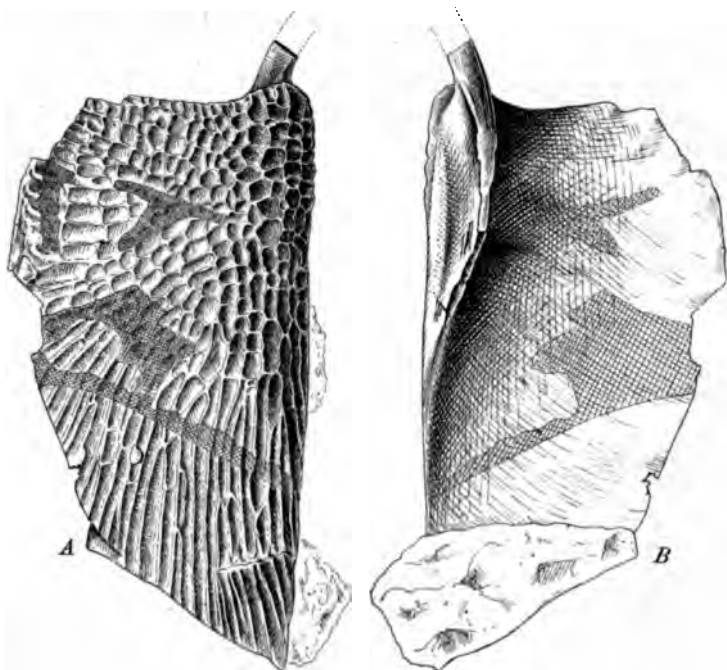
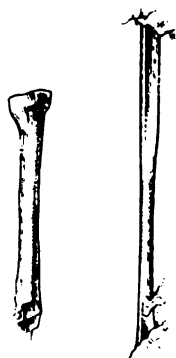


Fig. 18. Left labyrinthodont clavicular plate (?*Eupelor durus* Cope) (No. 2324).
 $\times \frac{1}{4}$. A, outer, B, inner aspect.

One of these bones (Fig. 19) shows one natural extremity with a diameter of 2.5 mm., but the straight tiny bone has only a diameter of 1 mm. The other end is broken off. The preserved length of the bone is 17 mm. (with a short bit of impression). The broken end shows the bone to be hollow, with very thin walls.

The second bone (Fig. 20) is quite straight, also with a diameter of 1 mm. Both extremities are hidden in the rock. Its visible length is 21.5 mm.

Although it is impossible to determine such fragmentary bones, they are of some interest because of the possibility of belonging to pterosaurs. H. v. Meyer had described similar bones from the uppermost Triassic of Württemberg as probably belonging to pterosaurs.



Figs. 19 and 20.
 Two possibly pterosaurian bones (No. 2338). $\times 2$.

NOTE.—All of these teeth, etc., are found in black limestone and marl of Triassic age in the Phoenixville tunnel, York Co., Pa.

All references to the literature will easily be found in the 'Bibliography and Catalogue of the Fossil Vertebrata of North America, by O. P. Hay, Washington, 1902.

**Article XX.—THE BIRDS OF THE AMERICAN MUSEUM OF
NATURAL HISTORY'S ASIATIC ZOOLOGICAL
EXPEDITION OF 1916–1917**

BY OUTRAM BANGS

The birds collected by Roy Chapman Andrews and Edmund Heller in Burma, Yunnan and Fokien during the course of The American Museum of Natural History's Asiatic Zoological Expedition of 1916–1917, were very kindly placed in my hands for identification by Dr. Frank M. Chapman, and I now take pleasure in submitting the following annotated list.

The collecting of mammals was the primary object of the expedition and birds were to some extent a secondary consideration, which accounts for the short series, many of the species being represented by only a single specimen. The shortness of the series renders subspecific identification in a few instances a matter of some uncertainty.

The Expedition traveled along the border of Burma and Yunnan, and in western Yunnan to the Snow Mountains, and made one trip eastward to Yunnan Fu. An interesting detailed account of the wanderings and experience of the members of the party, with descriptions of all stations at which specimens were collected, and illustrated by many photographs and a sketch map of the route, has been published by Mr. Andrews.¹

The collection of birds made in Fokien was supplemented by a series of skins received on the spot from Rev. Harry R. Caldwell. This collection is included here with the others.

I have kept the birds from Fokien apart from those of Burma and Yunnan, giving two separate lists. This has caused very little repetition of names and has made no faunal confusion, which would have been the case had all been listed together.

Long after this paper was originally written Lord Rothschild published an article (*Novitates Zoologicae*, XXVIII, pp. 14–67, May 1921) on a collection of birds numbering 1442, made in 1918 and 1919 by George Forrest in west-central and north-western Yunnan.

Many changes in current names occur in this article and, as might be expected, much that I had said in my original MS. is anticipated. All this has now been rewritten and so far as the material in the Andrews Collection will allow I follow Lord Rothschild's opinions.

¹"*Camps and Trails in China.*" Appleton & Co. New York, 1918.

BIRDS FROM THE BURMA BORDER AND YUNNAN

PHASIANIDÆ

***Francolinus pintadeanus phayrei* (Blyth)**

Two males: Malipa, Burma, March 13, 1917; and Namting River, Burma border, March 4, 1917. These skins agree with one from Mengtsz, Yunnan, and one from Siam in the Museum of Comparative Zoology in being much smaller in all dimensions than specimens from southern China (Fokien, etc.). The wing ranges from 138 to 143 mm., with all other measurements proportionately small. I cannot detect any constant differences in color in the two races. Blyth's type was from Arakan, and his description reads: "Closely resembling in plumage the Pintado Partridge of the Mauritius, *Francolinus perlatus*, but of a less robust form and the male armed with well-developed spurs." The measurements given lately by Robinson and Kloss (1919, *Ibis*, (11) I, July, p. 408) for birds from South Annam are also small.

***Arboricola torqueola* (Valenc.)**

One adult female: No-mu-shu Pass, Yunnan, 8000 feet altitude, April 7, 1917. The oviduct contained eggs nearly ready for laying.

***Arboricola brunneipectus brunneipectus* Tickell**

One adult male: Namting River, Burma border, March 2, 1917.

***Coturnix coturnix japonica* Temminck and Schlegel**

One adult female: Malipa, Burma, March 13, 1917.

***Bambusicola fytchei fytchei* Anderson**

Two adult females: Mu-cheng, Salwin drainage, February 10, 1917; Teng-Yueh, Yunnan, April 22, 1917.

These skins like Rothschild's are wholly referable to *Bambusicola fytchei fytchei* Anderson, type locality Pouse, western Yunnan, and differ from *B. f. hopkinsoni* Godwin-Austen of Assam, etc., as pointed out by Rothschild.

I am loath, however, to throw the Mengtsz bird *B. f. oleaginea* Bangs and Phillips into the synonymy of true *fytschei* as Rothschild was inclined to do. The type, to be sure, is the only individual I have seen, but it differs more from *fytschei* than does *fytschei* from *hopkinsoni*. The spots on the upper parts are much blacker, these black spots extending even all over the hind neck; the ground color of the upper parts is darker olive

and the top of the head much darker; all the wing coverts, the scapulars and the back are much more uniform in color, hardly at all varied with paler, grayish cross markings and vermiculations; the chest is darker and very uniform—but little spotted.

Until a series from Mengtsz, which might, of course, prove the type to be an exceptional specimen, is available, I prefer to recognize three forms.

Tragopan temmincki (J. E. Gray)

One adult male: Ho-mu-shu Pass, Yunnan, 8000 feet altitude, April 8, 1917.

Gennaeus nyctemerus ripponi Sharpe

One fine adult, male: Ho-mu-shu Pass, Yunnan, 8000 feet altitude, April 7, 1917.

Phasianus colchicus elegans Elliot

Three adult males: Li-chiang Fu, Yunnan, 9000 feet altitude, October 25 and November 4, 1916.

Rothschild regretted his inability to compare Szechwan and Yunnan adults of this species and so be sure that *P. elegans* and *P. sladeni* (*nomen nudum*) were identical. This I have done, comparing four adult males from Szechwan with four adult males from Yunnan, and can find no constant differences either in size or in color.

Calophasis humiae Hume

One female: Teng-yueh Ting, Yunnan, April 22, 1917.

Chrysolophus amherstiae (Leadbeater)

Four adult males: Wan-tien, 7000 feet; Pei-ti-ping, Mekong River drainage, 9000 feet; and Li-chiang Fu, 11,000 feet altitude, November and December 1916 and May 14, 1917.

Gallus gallus ferrugineus (Gmelin)

Five specimens, three adult males, two adult females; Chang-lung, Salwin River, Yunnan; Namtung River, Burma border; and Malipa, Burma, February and March 1917. The distinction Stuart Baker (1917, Journ. Nat. Hist. Soc. of Bombay, XXV, p. 18) makes between the Indian and the Chino-Malayan Jungle Fowls is shown to a certain extent in the series of birds I have examined, though I find it very difficult to distinguish some specimens.

Pavo muticus Linnæus

One adult female: Chang-lung, Salwin River, Yunnan, 2000 feet altitude, March 21, 1917. The oviduct contained partly formed eggs.

TURNICIDÆ**Turnix pugnax rostrata** Swinhoe

One adult female: Chu-tung, Yung-ping Ho, Yunnan, 5000 feet altitude, January 17, 1917.

COLUMBIDÆ**Columba hodgsonii** Vigors

Three males: Chang-lung, Yunnan, 2000 feet altitude, and Malipa, Burma, March 1917

Streptopelia orientalis orientalis (Latham)

Three specimens, two males and a female: Ho-mu-shu Pass, Yunnan, 8000 feet altitude, April 8, 1917, and Malipa, Burma border, 3000 feet, March 10 and 14, 1917.

Rothschild referred his one specimen to this form without comment. Our three skins show a decided approach to *S. o. agricola* (Tickell); No. 143299 from Ho-mu-shu Pass in particular. This specimen, I think, might almost as well be referred to one form as to the other.

Streptopelia chinensis tigrina (Temminck and Knip)

One adult female: Namting River, Burma border, February 28, 1917. This example is perfectly typical.

RALLIDÆ**Amaurornis phoenicura chinensis** (Boddaert)

Three adults, two males and a female: Namting River, Burma border, March 4, 1917; Malipa, Burma, March 14, 1917; and Meng-peng, Salwin drainage, March 17, 1917.

CHARADRIIDÆ**Hoplopterus ventralis** (Wagler)

Two adult females: Meng-ting, Yunnan, February 16 and 17, 1917.

Scolopax rusticola rusticola Linnaeus

One male: Namting River, Burma border, March 1, 1917.

ARDEIDÆ***Bubulcus ibis coromandus* (Boddaert)**

One immature female: Lung-ling, Yunnan, March 28, 1917.

FALCONIDÆ***Lophospiza trivirgatus ruftinctus* (McClellan)**

One male, Namting River, Burma border, February 24, 1917. This specimen has a wing of 230 mm.

***Spilornis cheela ricketti* Selater**

One adult male: Malipa, Burma border, March 14, 1917. This is a large bird with a wing of 455 mm. and without much doubt belongs to this race lately described by Selater.

***Cerchneis tinnunculus saturatus* (Blyth)**

One "male" (female): Hung-chang, Yunnan, January 28, 1917.

BUBONIDÆ***Glaucidium cuculoides cuculoides* (Gould)**

One adult female: Namting River, Burma border, March 1, 1917.

CORACIDÆ***Coracias affinis* McClellan**

Three specimens, two males and a female: Hsiao, Meng-ting and Cheng-kang, Salwin drainage, February 3 and 6; and Shui-chai, Mekong River, Yunnan, January 19, 1917. All three are large birds like those from the eastern Himalayas, with wings ranging from 193 to 196 mm. Specimens in the Museum of Comparative Zoology from Cochin China are smaller, as also is one listed by Kloss from Siam. The smaller form of Cochin China and Siam, if really separable, should be known as *C. affinis theresiæ* Parrot. It, however, was not recognized by Kloss (1918, *Ibis*, (10) VI, January, p. 91), nor by Robinson and Kloss (1919, *Ibis*, (11) I, July, p. 421).

ALCEDINIDÆ***Halcyon smyrnensis fusca* (Boddaert)**

One adult female, Meng-ting, Burma border, February 18, 1917.

BU CEROTIDÆ***Anthracosceros malabaricus affinis* (Blyth)**

Two specimens, an adult male and an immature (sex not determined): Namting River, Burma border, February 28, 1917. These birds belong to the large Himalayan form, the adult male having a wing of 308 mm.

UPUPIDÆ***Upupa epops saturata* Lönnerberg**

One adult male: Yung-chang Fu, Yunnan, January 28, 1917. This is a large bird, with a wing of 154 mm. In size, as well as in other respects, it is an extreme example of the northern *saturata*.

MEROPIDÆ***Melittophagus leschenaulti swinehoi* (Hume)**

Three adults, a male and two females: Chang-lung, Salwin River, Yunnan, March 18, 19, and 21, 1917.

TROGONIDÆ***Pyrotrogon erythrocephalus erythrocephalus* (Gould)**

One adult male: Namting River, Burma border, March 30, 1917.

Rothschild referred a male and a female from Shweli-Salwin Divide to *P. e. yamakanensis* (Rickett) of Fokien. Our specimen certainly does not represent that form, of which I have seen one fully adult male. I have no hesitation in calling it true *erythrocephalus*.

CUCULIDÆ***Cuculus canorus bakeri* Hartert**

Two adult males: Teng-yueh Ting and Wa-hui, Yunnan, April 22 and May 16, 1917. On the label of one (killed April 22 at Teng-yueh Ting) is written: "Note *ku-ku*-calling throughout the day." These two specimens seem to me to be *bakeri*. They are quite as heavily barred below as in *C. canorus canorus*, and the color of the upper parts is as dark as in *C. optatus*. They have small bills, smaller than in *C. optatus*.

***Centropus sinensis intermedius* (Hume)**

Five specimens, both sexes: Namting River, Burma border; Chang-lung, Salwin River; Meng-ting, Yunnan; February 18, 22, and 28, and March 2 and 22, 1917. These specimens undoubtedly belong to the smaller form; the wing in the four females ranges from 205 to 216 mm. In the single male it is 200 mm.

Rhopodytes tristis tristis (Lesson)

One adult male: Chang-lung, Salwin River, Yunnan, March 20, 1917. This specimen, with a wing of 163 mm., I refer to the larger northern form.

CAPITONIDÆ**Cyanops asiatica** Latham

Two specimens, male and female: Chang-lung, Salwin River, Yunnan, March 20 and 21, 1917.

Cyanops franklini franklini (Blyth)

One adult male: Tai-ping-pu, Yunnan, April 12, 1917.

Xantholaema hæmacephala indica (Latham)

One adult male: Namting River, Burma border, February 28, 1917.

PICIDÆ**Picus canus sordidior** (Rippon)

Three adults, two males and a female: Hui-yao, Yunnan, 5000 and 5500 feet altitude, May 7, 1917; and Malipa, Burma border, 3200 feet altitude, March 14, 1917.

Hypopicus hyperythrus subrufinus (Cabanis and Heine)

Two adult males: Li-chiang Fu, Snow Mountains, Yunnan, 10,000 feet altitude, November 16, 1916.

Dryobates pernyi pernyi (Verreaux)

One adult male: Li-chiang Fu, Snow Mountains, Yunnan, 10,000 feet altitude, November 16, 1916.

Chrysocolaptes guttacristatus sultapeus Hodgson

Two adult males: Malipa, Burma border, February 22, 1917. These are large birds, with the wings 176 and 178 mm. respectively and with heavy bills, and must, therefore, I suppose, be referred to this form.

Thriponax javensis feddeni (Blanford)

One adult male: Malipa, Burma border, March 15, 1917.

Jynx torquilla japonica Bonaparte

One adult female: Yung-chang Fu, Yunnan, January 28, 1917.

EURYLAIMIDÆ**Serilophus lunatus lunatus** Gould

One male: Meng-ting, Burma border, February 19, 1917. Apparently referable to this form.

HIRUNDINIDÆ**Hirundo rustica gutturalis** Scopoli

One adult male: Meng-ting, Burma border, February 18, 1917.

Hirundo daurica nipalensis Hodgson

One adult, sex not determined: Meng-ting, Salwin drainage, Yunnan, February 19, 1917.

Ptyonoprogne rupestris (Scopoli)

One female: Chen-kang, Salwin drainage, Yunnan, February 6, 1917.

MUSCICAPIDÆ**Cyornis tickelliae whitei** Harington

One adult male: Chang-lung, Salwin River, Yunnan, 2000 feet altitude, March 21, 1917.

Niltava sundara denotata Bangs and Phillips

Three adult males: Chang-lung, Salwin River and Tai-ping-pu, Yunnan, March 18 and 20, and April 9, 1917. These skins exactly match the type of the subspecies and differ from true *N. sundara* in having the back blacker, less purplish, and the under parts much paler and yellower and in longer wing.

Rothschild hesitates to recognize *denotata*, but again going over all material available to me I am still inclined to do so.

Muscicapula melanoleuca melanoleuca (Blyth)

Four specimens: Tai-ping-pu, Yunnan, April 12 and 13, 1917.

Rhipidura albicollis albicollis (Vicillot)

Three adults, two males and a female: Namting River, Burma border, and Mu-cheng, Salwin drainage, Yunnan, February 25 and March 5, 1917.

As well as I can determine these skins with the limited Indian material available to me, which does not include an example from the region assigned by Baker to his form, *stanleyi*, they do not belong to the northern and north-eastern race, characterized by Baker (1913, Records of the Indian Museum, VIII, part 3, September, p. 275) as *Rhipidura albicollis kemp*i, new subspecies. The specimens recorded by Phillips and myself from Mengtsz are quite the same in color as those in the present collection.

The name *kemp*i given by Baker was preoccupied by *Rhipidura rufifrons kemp*i Mathews (1912, Nov. Zool., XVIII, January, p. 320) and was changed later by Baker to *stanleyi*. It was, however, again used for still another bird, *Rhipidura flabellifera kemp*i Mathews and Iredale of North Island, New Zealand (Ibis, 1913, p. 441), which may be called *Rhipidura flabellifera placabilis*, new name.

***Culicicapa ceylonensis ceylonensis* (Swainson)**

Three adults, two male and a female; Namting River and Malipa, Burma border, and Tai-ping-pu, Yunnan, February 22, March 16, and April 12, 1917.

***Stoparola thalassina thalassina* (Swainson)¹**

One adult male: Mu-cheng, Salwin drainage, Yunnan, 5000 feet altitude, February 15, 1917.

CAMPEPHAGIDÆ

***Pericrocotus speciosus speciosus* (Latham)**

One adult male: Ta-shui-tang, Salwin drainage, Yunnan, 6000 feet altitude, February 2, 1917.

***Pericrocotus yvettae*,² new species**

Two specimens, an adult male and an adult female: Malipa, Burma border, and Taiping-pu, Yunnan, March 10 and April 12, 1917.

TYPE.—Amer. Mus. of Nat. Hist. No. 143365; adult male; Malipa, Burma border, 3000 feet altitude, March 10, 1917; R. C. Andrews and E. Heller.

CHARACTERS. Adult male similar to the adult male of *P. xanthogaster xanthogaster* (Raffles) and with the four outer primaries without red but slightly larger, and red on secondaries continuous from base to near tip on outer webs of feathers

¹For change in the specific name from *melanops* Vig. to *thalassina* (Swainson), see Oberholzer, 1919, Proc. Biol. Soc. Wash., XXXII, p. 240, December 31.

²Named in honor of Mrs. Andrews.

(in *P. xanthogaster* the red on the secondaries is arranged in spots near the tips of the feathers which are separated from the red bases by black); red of under parts nearly scarlet-red (nearly scarlet in *P. xanthogaster*). Adult female similar to the female of *P. xanthogaster*.

MEASUREMENTS

A. M. N. H. No.	Sex	Wing	Tail	Tarsus	Culmen
143365	♂ ad.	94 mm.	105 mm.	14.5 mm.	11 mm.
143367	♀ ad.	87	94	14.0	11

I feel a little hesitation in describing this form on the strength of one adult male, still I have been unable to match this specimen at all nearly, nor can I find the description of a Minivet which could apply to this one. The female, which I refer to this species because it certainly is not the female of *brevirostris* or *speciosus*, I cannot distinguish from females of *P. xanthogaster* from Sumatra in color or markings, except that in this one example there is no yellow on the secondaries except at the base.

The red markings in the wing of the male are very striking, giving two broad red stripes down the closed wing, with black between them, one along the primaries, the other along the secondaries.

***Pericrocotus brevirostris ethologus* Bangs and Phillips**

One adult male: Tai-ping-pu, Yunnan, April 12, 1917. This is an intensely colored individual not extremely typical of this form. When Phillips and I (1914, Bull. Mus. Comp. Zool., LVIII, No. 6, pp. 282-283) divided this species into three subspecies we allowed a typographical error to creep into one of our new names, which we did not detect till long afterward, probably because the printed *fl* and *f* look so alike. The name we gave the more western subspecies should be *Pericrocotus brevirostris favillaceus* (favillaceus, like glowing ashes or embers) not "flavillaceus," as it appeared, which has no meaning. I believe even at this late date the rules of nomenclature allow such a correction to be made.

PYCNONOTIDÆ***Ægithina tiphia tiphia* Linnæus**

One male in green plumage: Chang-lung, Yunnan, March 19, 1917.

***Chloropsis hardwickii* (Jardin and Selby)**

Four adults, both sexes: Chang-lung and Mu-cheng, Salwin River, Yunnan, February 15 and March 18 and 21, 1917.

***Chloropsis icterocephala chlorocephala* (Walden)**

Two males: Namting River, Burma border, February 21 and 28, 1917.

***Hypsipetes leucocephalus* (Gmelin)**

Two adults, male and female: Namting River, Burma border, and Yoakuan, Yunnan, January 21 and February 21, 1917.

The male of this pair has a pure white head, neck, and chest; the rest of the under parts are clear ashy gray with no black intermixed. Such a condition of plumage is apparently rare. Most birds with pure white heads have the under parts black or much mixed with black. One or two, however, in a long series from other parts of China match this one.

The female I at first inclined to refer to some other species. Like the male, it has no black on the under parts, which are wholly gray, but there is no white at all on its head. I have seen some skins, however, from Hupeh and Mengtsh, Yunnan, that have hardly any white on the head and that almost match it. It has no black on the cheek and therefore cannot be referred to *H. concolor* Blyth.

The extraordinary range of variation in color in this species seems to be individual rather than due to age. I have before me black-breasted birds with wholly white heads and others with only a few white feathers in the head, and gray-breasted birds with and without white heads, and all sorts and kinds of intermediates.

***Hemixus flava flava* (Hodgson)**

One male: Chang-lung, Salwin River, Yunnan, March 19, 1917.

***Iole maclellandi similis* Rothschild**

One male: Ta-shiu-tang, Salwin drainage, Yunnan, February 3, 1917.

***Alcurus striatus* (Blyth)**

One adult female: Tai-ping-pu, Yunnan, April 9, 1917.

***Molpastes cafer burmanicus* (Sharpe)**

Three adults, two males, one with sex not determined: Yung-chang Fu, Yunnan, January 24, 27, and 28, 1917.

***Pycnonotus xanthorrhous xanthorrhous* J. Anderson**

Four adults, both sexes: Wan-tien, Li-chiang Fu, Chang-lung, and Hui-yao, Yunnan, November 11, 1916, March 19, and May 1, 16 and 17, 1917. These are, of course, true *xanthorrhous* of Anderson. A large series collected by Zappey in Hupeh represents quite a different form, distinguished by being slightly larger, paler brown above, and with the brown band across the chest much paler and less sharply contrasted. This is *Pycnonotus xanthorrhous andersoni* (Swinhoe); type locality, Ichang.

Otocompsa emeria emeria (Linnæus)

Six adults, both sexes: Malipa, Burma; Chang-lung and Mengting Yunnan, February 17, March 12 and 21, 1917.

Otocompsa flaviventris flaviventris (Tickell)

One adult male: Chang-lung, Yunnan, March 19, 1917.

Spizixos canifrons Blyth

Five adults, both sexes: Tai-ping-pu and Chen-kang, Yunnan, February 7 and April 8, 9, and 12, 1917.

TIMELIINÆ**Ianthocincla lanceolata lanceolata** J. Verreaux

One adult male: Mu-cheng, Salwin drainage, Yunnan, February 13, 1917. I cannot distinguish this skin in any way from specimens from the mountains of Hupeh.

Ianthocincla lanceolata bonvaloti (Oustalet)

One adult male: Li-chiang, Snow Mountains, Yunnan, 10,000 feet altitude, November 16, 1916. This specimen is indistinguishable from examples taken by Zappey in the high mountains, 9000 to 14,000 feet altitude, of extreme western Szechwan.

These two specimens are both in unworn, fresh plumage and I have had ample material, collected by Zappey in Hupeh and Szechwan, with which to compare them.

It is interesting to get both forms in Yunnan, and there as in southwestern China to find the small paler form, *lanceolata*, at lower and the large darker form, *bonvaloti*, at higher altitudes.

In the series now before me, in 7 adults of *lanceolata* the wing ranges from 91 to 98 mm.; in 4 adults of *bonvaloti* from 106–113. In fresh plumage *bonvaloti* is darker than *lanceolata* with the browns of the head and back deeper and richer, and the stripes on the under parts both heavier and darker in color.

Ianthocincla erythrocephala woodi (Stuart Baker)

One adult male: Mu-cheng, Salwin drainage, Yunnan, February 14, 1917; "caught in a steel trap set in the forest." This skin agrees very well with Stuart Baker's description and undoubtedly represents the very distinct form recently described by him. It, No. 143413 Amer. Mus. of Nat. Hist., affords the following measurements: Wing, 104; tail, 119; tarsus, 41.5; exposed culmen, 20 mm.

***Ianthocincla ellioti* (Verreaux)**

One adult male: Li-chiang, Snow mountains, Yunnan, 10,000 feet altitude, November 9, 1916. After a very careful comparison of this skin with the long series collected by Zappey in Hupeh and Szechwan, I can detect not the slightest difference.

Rothschild reached the same conclusions from a study of his material, but hesitated to throw *I. ellioti honoripeta* Hartert, the supposedly darker Yunnan form into synonymy, thinking it might be a form that reached the province only on migration. I think there is little doubt that the name is a pure synonym.

***Ianthocincla cinereiceps styani* (Oustalet)**

One adult male: Malipa, Burma border, 3600 feet altitude, March 16, 1917. This specimen represents true *styani* with a black cap and yellowish-brown ear-coverts. The one skin taken February 6 and probably a migrant, recorded by Phillips and myself from near Mengtsz, Yunnan, under the name *styani* proves on comparison to be *I. c. cinereiceps* (Styan). The black cap, I have lately been told by La Touche, is only a sign of maturity, and is acquired by old birds of both forms. The two subspecies can, however, be distinguished easily by the colors of the ear-coverts and of the under parts.

***Pomatorhinus maccllellandi odicus* Bangs and Phillips**

Two adults, male and female: Mu-cheng, Salwin drainage, Yunnan, February 10 and 13, 1917. These agree exactly with the Mengtsze specimens upon which the subspecies was based.

***Garrulax leucolophus leucolophus* (Hardwick)**

Two males: Malipa, Burma, March 14, 1917. These seem to be quite typical, showing no characters even approaching those of *G. l. belangeri* Lesson.

***Garrulax pectoralis pectoralis* (Gould)**

One adult female: Malipa, Burma, March 14, 1917. This specimen appears to be nearer the bird of the Himalayas than it is to the southern *G. p. meridionalis* Stuart-Baker.

***Dryonastes chinensis chinensis* (Scopoli)**

Two adults, male and female: Chang-lung, Salwin River, Yunnan, 2000 feet altitude, March 18 and 21, 1917.

***Dryonastes sannio albosuperciliaris* (Godwin-Austen)**

Two adult females: Wan-tien and Mu-cheng, Yunnan, February 13 and May 14, 1917. With ample material I now have no hesitation in recognizing two forms of *D. sannio*: *D. sannio sannio* (Swinhoe), central and southeastern China, more reddish olive above with more rusty tail, and *D. s. albosuperciliaris* (Godwin-Austen), Manipur to Yunnan, olive above with much less rusty tail.

***Pellorneum ruficeps minus* Hume**

Two adults, male and female: Chang-lung, Salwin River, Yunnan, and Malipa, Burma border, March 15 and 23, 1917. These two skins are, I think, best called *minus*, though they appear to be somewhat intermediate between that form and *P. r. mandellii* Blanford.

***Drymocapthus tickelli tickelli* (Blyth)**

One male: Namting River, Burma border, 1700 feet altitude, February 25, 1917; "caught in a rat trap set in the forest." I have seen no other skins of this species and have identified the specimen as best I can by Harington's 'Notes on the Indian Timelliides and their Allies' (1915, Journ. Bomb. Nat. Hist. Soc., XXIII, p. 435). He thinks true *tickelli* and *assamensis* Sharpe will prove to be one and the same. Certainly this skin is not "rufescent" olive-brown above.

***Alcippe phaeocephala magnirostris* Walden**

One adult male: Namting River, Burma border, 1700 feet altitude, February 21, 1917. This specimen, with no whitish eye-ring and very well-marked black stripes on the side of the head, I refer without much doubt to this form, of which, however, I have seen no other examples.

***Shoeniparus genestieri* (Oustalet)**

Three specimens, two males and a female: Ho-mu-shu Pass, 8000 feet altitude, and Mu-cheng, Salwin drainage, 7000 feet altitude, Yunnan, February 10 and April 4, 1917.

***Mixornis rubricapilla sulphurea* (Rippon)**

Two adults, male and female: Meng-ting, Burma border, and Chang-lung Salwin drainage, Yunnan, February 18 and March 18, 1917.

***Myiophonus eugenei eugenei* Hume**

Four adults, both sexes: Namting River, Burma border, and Yung-chang, Yunnan, January 28, February 18 and 28, and March 2, 1917.

Rothschild is wholly right in his suspicion that *M. eugenei* and *M. tibetanus* Madarász are in reality one and the same. The skins of the so-called *tibetanus* collected by Zappey in high western Szechwan are in every way like Yunnan specimens of *eugenei*. 'This I detected long ago, when we first received a series of *eugenei*.

***Lioptila annectens annectens* Blyth**

One adult male: Mu-cheng, Salwin drainage, Yunnan, 5000 feet altitude, February 15, 1917. The flanks and undertail coverts in this specimen are rather paler, otherwise it agrees with birds in the Museum of Comparative Zoölogy from Manipur with the back Sanford's brown. *L. annectens saturatus*, which I have not seen, is said to have the back "rich, deep chestnut."

***Lioptila desgodinsi* (David and Oustalet).**

Two adults, male and female: Tai-ping-pu and Yao-kuan, Yunnan, 6000 to 7000 feet altitude, January 31 and April 12, 1917.

***Staphidia striata* (Blyth)**

One adult male: Chang-lung, Salwin River, Yunnan, 2000 feet altitude, March 20, 1917.

***Siva cyanuroptera wingatei* Ogilvie-Grant**

Two adults, male and female: Hui-yao and My-cheng, Yunnan, February 10 and May 1, 1917.

***Yuhina diademata ampelina* Rippon**

Two adults, male and female: Li-chiang, Snow Mountains, 10,000 feet altitude, November 11 and 12, 1917. These specimens are no darker than examples from Hupeh and Szechwan—in fact, one of them is lighter in color than true *diademata*. I might add that, in comparing examples of this species, it is well to compare only those taken at approximately the same season of the year, spring and summer specimens being much lighter in color than autumn and winter ones.

I follow Rothschild in the name used for the bird of western Yunnan, as I am afraid I do not know the real characters of *ampelina*.

***Yuhina occipitalis obscurior* Rothschild**

Two adults, male and female: Lung-ling, Yunnan, March 27, 1917.

***Ixulus flavicollis rouxi* Oustalet**

One adult male: Tai-ping-pu, Yunnan, April 2, 1917.

Cutia nepalensis nepalensis Hodgson

One adult male: Ho-mu-shu Pass, Yunnan, 8000 feet altitude, April 5, 1917.

Pterythius serralatus ricketti Ogilvie Grant

One adult female: Ho-mu-shu Pass, Yunnan, 8000 feet altitude, April 7, 1917. There is a note on the label of this specimen reading "contained eggs."

Mesia argentaureis argentaureis Hodgson

One adult male: 20 miles south of Chen-kang, Salwin drainage, Yunnan, February 7, 1917.

TROGLODYTIDÆ**Spelæornis souliei** Oustalet

One male: Tai-ping-pu, Yunnan, 7000 feet altitude, April 12, 1917; "caught in a rat trap set in the forest." I have compared this skin with Oustalet's description and believe it to belong to the species he described as *souliei*. It is, however, the only specimen of the species that I have seen.

Pnoepyga pusilla pusilla Hodgson

Two specimens, male and female: Ho-mu-shu Pass, Yunnan, 7000 feet altitude, and Namting River, Burma border, 1700 feet altitude, February 25 and April 8, 1917. Both examples were caught in traps set for small mammals in the forest.

TURDIDÆ**Turdus merula mandarinus** Bonaparte

Two adults, male and female: Yung-chang, Yunnan, January 24 and 29, 1917.

Turdus castaneus gouldi (Verreaux)

Four specimens, three adults, both sexes, and an immature female: Li-chiang, Snow Mountains, 10,000 feet altitude, Yoa-kuan, and Tai-ping-pu, Yunnan, November 10 and 14, 1916, January 31 and April 10, 1917.

Turdus dissimilis Blyth

Two adults, male and female: Chang-lung, Salwin River, Yunnan, March 18, 1917.

***Turdus auritus conquisitus*, new subspecies**

TYPE and only specimen.—No. 143452, Amer. Mus. of Nat. Hist.; adult female; Li-chiang, Snow Mountains, 10,000 feet, Yunnan; November 16, 1916; R. C. Andrews and E. Heller.

CHARACTERS.—Similar to *Turdus auritus auritus* Verreaux, but under parts much more heavily spotted with black, especially on sides and flanks, all the spots larger and more intensely black less brownish black. Wing, 124 mm.; tail, 91 mm.; tarsus, 36 mm.; culmen, to base of forehead, 23.

When I first compared the Yunnan skin with one adult of *T. a. auritus*, collected by Zappey in western Szechwan, both killed in November, I was at once struck by the great difference in the spotting of the under parts and made a note to that effect but did not name the Yunnan bird having only one skin from each region. Since then Rothschild has called attention to exactly the same difference shown by his one adult from Yunnan, compared with his one adult from the Tsin Ling Mountains, and now no reason remains for not giving the Yunnan form a name.

***Turdus mollissimus* Blyth**

One adult female: Li-chiang, Snow Mountains, Yunnan, 10,000 feet altitude, November 9, 1916; "caught in a steel trap."

***Monticola solitarius pandoo* (Sykes)**

One adult male: Tung-chang Fu, Yunnan, January 26, 1917.

***Monticola erythrogaster* Vigors**

One adult male: Ho-mu-shu Pass, Yunnan, 8000 feet altitude, April 9, 1917.

***Enicurus schistaceus* Hodgson**

One female: Namting River, Burma border, February 25, 1917.

***Chimarrhornis leucocephala* (Vigors)**

Two adults, male and female: Mu-cheng, Salwin drainage, and Yuan-chiang-Chou, Yunnan, January 26 and February 16, 1917.

***Phoenicurus hodgsoni* (Moore)**

Two specimens, male and female: Yung-chiang-chou, Yunnan, January 27, 1917.

***Calliope calliope calliope* (Pallas)**

Two adults, male and female: Namting River, Burma border and Chang-lung, Yunnan, March 2 and 21, 1917.

***Ianthia ruflata practica* Bangs and Phillips**

Two specimens, male and female: Mu-cheng, Yunnan, February 10 and 14, 1917. The male, a fine adult in full plumage, has the blue parts of its plumage a little deeper and slightly more purplish than in the type of *practica*. There is also some slight white at the bases of the superciliaries.

***Notodela leucura* (Hodgson)**

Two adult males: Namting River, Burma border, 1700 feet altitude, February 20 and 21, 1917. These two specimens show a wing measurement of 95 mm. in one and 97 mm. in the other.

***Copsychus saularis saularis* (Linnæus)**

One female: Meng-ting, Burma border, February 18, 1917.

***Saxicola torquata przewalskii* Pleske**

Three specimens, two males and a female: Yung-chang Fu, Yunnan, January 27 and 28, 1917.

***Oreicola jerdoni* Blyth**

One adult male: Namting River, Burma border, February 22, 1917.

***Oreicola ferrea haringtoni* Hartert**

Three specimens, a male and two females: Malipa, Burma border, and Wan-tien, Yunnan, March 14 and May 14, 1917.

SYLVIIDÆ***Megalurus palustris andrewsi*,¹ new subspecies**

Two adult males: Malipa, Burma, and Meng-ting, Burma border, February 18 and March 14, 1917.

TYPE.—No. 143478, Amer. Mus. of Nat. Hist.; adult male; Meng-ting, Burma border; February 18, 1917; R. C. Andrews and E. Heller.

CHARACTERS.—Similar to *M. palustris palustris* Horsford from Java and of about the same size, differing in the black striping of the upper parts being wider and more intensely black; the brown of upper parts deeper, brighter, more reddish brown, especially on the crown. The general color of upper parts in *M. palustris palustris* is clay-color to buck-thorn brown; general color of upper parts in the new form is ochraceous tawny, almost tawny on the crown.

¹Named in honor of Roy Chapman Andrews.

MEASUREMENTS

	Sex	Locality	Wing	Tail	Tarsus	Exposed Culmen
A. M. N. H. No. 143478	♂	Burma border Meng-ting	107 mm.	135 mm.	41 mm.	17.5 mm.
A. M. N. H. No. 143477	♂	Burma Malipa	106	133	42	18.0
M. C. Z. No. 34207	♀	India Buxa Doars	94	124	37	16.0

I cannot find that the Indian and Burmese form has ever been separated from the typical Javanese bird. Gray (1848, 'Gen. Birds,' I, p. 169, Pl. XLVIII) figured a young bird in the very yellowish plumage and named it *Megalurus citrinus*. He did not state where his specimen was from, and Sharpe in Vol. VII of the catalogue of birds does not claim the type in the British Museum. I believe the young as figured by Gray could not be positively identified as that of either one or the other subspecies.

Both the Javanese and Burmese forms are much browner, less grayish, than the Philippine bird, *M. palustris forbesi* Bangs.

***Phylloscopus fuscatus* (Blyth)**

One female: Yuan-chiang-Chou, Yunnan, January 27, 1917.

***Phylloscopus davisoni* (Oates)**

One male: Wan-tien, Yunnan, May 15, 1917.

***Phylloscopus proregulus forresti* Rothschild**

One male: Yung-chang Fu, Yunnan, January 27, 1917.

This specimen, in winter plumage, fits the description of the lately described *forresti* well, except that it has the extreme base of the lower mandible of a pale color.

***Phylloscopus humei præmium* Mathews and Iredale**

One male: Chang-lung, Salwin River, Yunnan, March 21, 1917. This is, of course, the bird we used to know as *P. superciliosus superciliosus* (Gmelin).

***Phylloscopus lugubris* (Blyth)**

One male: Wan-tien, Yunnan, May 15, 1917.

***Horornis canturians* (Swinhoe)**

Two males: Yung-chang Fu, Yunnan, January 28, 1917.

***Prinia inornata extor* Thayer and Bangs**

Two females: Yung-chang Fu, Yunnan, January 27, 1917.

PRIONOPIDÆ***Hemipus picatus capitalis* (McClellan)**

One male: Chang-lung, Salwin River, Yunnan, March 20, 1917.

LANIIDÆ***Lanius schach tephronotus* (Vigors)**

Two specimens, adult male and immature male: Yung-chang Fu, Yunnan, January 27 and 28, 1917.

***Lanius nigriceps nigriceps* Franklin**

One adult female: Meng-ting, Burma border, February 18, 1917.

***Lanius colluroides* Lesson**

Two adult females: Chang-lung and Yung-chang Fu, Yunnan, January 28 and March 21, 1917.

PARIDÆ***Parus major commixtus* Swinhoe**

Two males: Yung-chang Fu, Yunnan, 5500 feet altitude, January 27 and 28, 1917. These skins, like many taken by Zappey in parts of western Szechwan, are not extreme *commixtus* but are nearer to it than they are to any of the other races. The wing measures 70 mm. in one of these and 74 mm. in the other.

SITTIDÆ***Sitta europea nagaensis* Godwin Austen**

One adult female: Ho-mu-shu Pass, Yunnan, 8000 feet altitude, April 4, 1917. This specimen is much grayer, less rusty below, than in any of our skins of *S. europea montium* LaTouche and, if the two are distinct, should, I believe, be referred to *magænsis*.

***Sitta frontalis corallina* Hodgson**

Three adult females: Malipa, Burma and Namting River, Burma border and Chang-lung, Salwin River, Yunnan, February 23 and March 13 and 20, 1917.

Indian and Burmese birds are slightly different from true *S. frontalis* of Java. They are somewhat paler below with a vinaceous rather than a lilaceous tinge and have a more extended white throat-patch.

I follow Hellmayr and unite all the true nuthatches in one genus, being loath to accept the excessive subdivision of the genus proposed by Buturlin in his recent (1911) review.

CERTHIDÆ

***Certhia discolor* Blyth**

One adult male: Tai-ping-pu, Yunnan, 7000 feet altitude, April 9, 1917.

ZOSTEROPIDÆ

***Zosterops palpebrosa simplex* Swinhoe**

Two adults, male and female: Chang-lung, Salwin River, Yunnan, and Malipa, Burma border, March 15 and 21, 1917.

DICÆIDÆ

***Dicaeum minullum olivaceum* Walden**

One female: Chang-lung, Salwin River, Yunnan, March 20, 1917.

NECTARINIDÆ

***Æthopyga ignicauda* (Hodgson)**

One immature male (in change from young to adult plumage): Yoakuan, Yunnan, 6000 feet altitude, January 31, 1917.

***Æthopyga nipalensis* (Hodgson)**

Two adults, male and female: Mu-cheng and Chang-lung, Yunnan, February 16 and March 18, 1917.

***Æthopyga dabryi* (J. Verreaux)**

Four adult males: Wan-tien, Ta-shui-tang and Mu-cheng, Yunnan, February 2, 3 and 16, and May 14, 1917.

MOTACILLIDÆ

***Motacilla alba hodgsoni* Blyth**

One adult female: Yung-chang Fu, Yunnan, January 27, 1917.

***Motacilla alba ocularis* Swinhoe**

One adult male: Yung-chang Fu, Yunnan, January 27, 1917.

***Motacilla cinerea melanope* Pallas**

One immature male: Yung-chang Fu, Yunnan, January 27, 1917.

Anthus hodgsoni Richmond

Two specimens, male and female: Yung-chang Fu, Yunnan, January 27 and 28, 1917.

Lately Uchida and Kuroda (1916, *Annotationes Zoologicae Japonenses*, IX, p. 134) have named a form from Yunnan *Anthus maculatus yunnanensis*, apparently based upon migrant birds. The only character ascribed to the new form is a smaller bill than in the typical bird. The two specimens listed above have rather small bills, but five winter birds from Mengtsz are quite like examples from anywhere else in this respect. In a good series of breeding birds from the high mountains of Hupeh and Szechwan I find a good deal of individual variation in the size of the bill, as also in breeding birds from Sachalin Island, and I do not believe *yunnanensis* is a recognizable form.

Sarundy, in 1909, named the breeding bird of south-western Kansu *Anthus maculatus berezowskii*, on the character of a grayer back with blacker shaft markings. I have seen no specimens from Kansu, but all mid-summer examples that I have examined show these two characteristics to a marked degree when compared with winter or spring killed individuals from the same regions.

I am inclined to believe that Rothschild, in using *berezowskii* as the name of the species, overlooked the fact that *A. hodgsoni* Richmond, as a substitute for the preoccupied *Anthus maculatus* Jerdon, dates from 1907, and *A. berezowskii* Sarundy dates from 1909; but perhaps he did not and meant to treat *berezowskii* as a species distinct from *hodgsoni*.

FRINGILLIDÆ**Eophona migratoria migratoria**¹ Hartert

One female: Yung-chang Fu, Yunnan, January 28, 1917.

Spinus ambiguus Oustalet

Two males: Yung-chang Fu, Yunnan, 5500 feet altitude, January 28, 1917.

Passer montanus montanus (Linnaeus)

One adult male: Yung-chang Fu, Yunnan, January 28, 1917. I cannot distinguish this specimen from European birds. It apparently does not approach *P. montanus malaccensis* Dubois of tropical India, Malaya, etc.

¹For the change of the specific name from *melanura* to *migratoria*, see Penard, 1919, *Proc. New Eng. Zool. Club*, VII, p. 22, October 31.

***Passer rutilans cinnamomea* (Gould)**

One adult male: Lung-ling, Yunnan, 5000 feet altitude, March 27, 1917.

Rothschild records the specimens taken by Forrest as *Passer rutilans assimilis* Walden. I cannot reconcile any Yunnan skin examined by me with Walden's description which calls for a bird with "the cheeks and sides of the neck pure white, and the breast, flanks and ventral region ashy grey." All specimens from Yunnan as well as those from western Szechwan that I have seen have yellow cheeks and sides of the neck, and are strongly washed with yellow all over the under parts, and appear to me indistinguishable from birds from the eastern Himalayas.

Zappey, however, took in Hupeh and eastern Szechwan seven sparrows that Thayer and I referred to *P. rutilans rutilans* (Temminck). These skins agree well with Walden's description, but I cannot see much difference between them and Japanese birds, except that some, not all, of them are intermediate between *rutilans* and *cinnamomea*.

***Carpodacus edwardsii* Verreaux**

One male in plumage similar to that of the female: Tai-ping-pu, Yunnan, April 9, 1917.

***Pyrrhula erythaca altera* Rippon**

One adult male: Li-chiang, Snow Mountains, Yunnan, 10,000 feet altitude, November 11, 1916.

***Emberiza pusilla* Pallas**

Three specimens, two males and a female: Malipa, Burma and Yung-chang Fu, Yunnan, January 28 and March 13, 1917.

***Emberiza spodocephala melanops* Blyth**

Two males: Chang-lung, Salwin River, Yunnan, March 21 and 24, 1917.

***Melophus melanicterus* (Gmelin)**

One immature male: Namting River, Burma border, February 23, 1917.

PLOCEIDÆ***Munia punctata topela* Swinhoe**

One immature female: Namting River, Burma border, February 28, 1917.

STURNIDÆ***Sturnia nemoricola* Jerdon**

Two females: Namting River, Burma border, and Chang-lung, Salwin River, Yunnan, February 25 and March 20, 1917.

***Gracupica nigricollis* (Paykull)**

Three adults, two males and a female: Meng-ting, Burma border, February 28, 1917.

***Acridotheres tristis* (Linnæus)**

Two adults, male and female: Shih-tien, Yunnan, January 30, 1917.

***Æthiopsar cristatellus cristatellus* (Gmelin)**

Seven adults, both sexes: Malipa, Burma, Yoa-kuan and Hsiao,¹ Salwin drainage, Yunnan, January 30, February 3, March 12 and 13, 1917; "often seen feeding on the backs of buffalo."

***Æthiopsar albocinctus* Godwin-Austen and Walden**

One adult female: Malipa, Burma, March 13, 1917.

ORIOLIDÆ***Oriolus indicus tenuirostris* Blyth**

One specimen (marked "♂," apparently a female): Yung-chang, Yunnan, January 26, 1917.

DICRURIDÆ***Chibia hottentotta hottentotta* (Linnæus)**

One adult male: Chang-lung Salwin River, Yunnan, March 21, 1917. This is a large billed bird; the bill measured as Stuart Baker (1919, Nov. Zool., XXVI, p. 44) measures his series gives 29 mm.

***Dicrurus leucophæus nigrescens* Oates**

Three adult males: Yung-chang and Chang-lung, Salwin River, Yunnan, January 27 and 28, March 22, 1917. These are all large birds (wing: 145, 146, and 140 mm.)

CORVIDÆ***Corvus coronoides levaillantii* Lesson**

One adult female: Li-chiang, Snow Mountains, Yunnan, 10,000 feet altitude, November 12, 1916.

¹"Hsiao" means in English "small, little."

***Corvus insolens* Hume**

One adult male: Meng-ting, Burma border, February 18, 1917.

***Nucifraga caryocatactes macella* Thayer and Bangs**

One adult male: Li-chiang, Snow Mountains, Yunnan, 10,000 feet altitude, November 6, 1916. On comparing this skin with the type of *macella* from the mountains of Hupeh and with one skin from Tachienlu, I can detect no differences that would seem to be subspecific. The type is a little paler brown than in either the Tachienlu or Yunnan specimens, but I cannot believe that this slight difference would prove to be constant. Also, the white spotting in the type of *macella* extends quite down the middle of the belly to the vent, whereas in the two other skins the whole belly is unspotted. If long series should show that *Nucifraga yunnanensis* Ingram (1910) is different from *N. macella* (1909) of Hupeh, then the Tachienlu bird must be referred to *yunnanensis*. For the present, I unite the two under the older name.

***Pica pica sericea* Gould**

Two adult females: Yung-chang Fu, Yunnan, January 27, 1917.

***Urocissa erythrorhyncha erythrorhyncha* (Gmelin)**

Four adults, both sexes: Hui-yao, 5500 feet altitude, and Li-chiang, Snow Mountains, 10,000 feet altitude, Yunnan, November 7, 9; and 12, 1916, and May 7, 1917.

***Dendrocitta himalayensis* Blyth**

Two adults, male and female: Wantien and Taipingpu, Yunnan, April 12 and May 14, 1917.

***Garrulus leucotis* Hume**

One adult male: Malipa, Burma, March 14, 1917.

***Garrulus bispecularis sinensis* Swinhoe**

One adult male: Lichiang, Snow Mountains, Yunnan, 10,000 feet altitude, November 11, 1916. This specimen has a grayish back and a whitish throat, wing 195 mm., and thus represents the variant named *rufescens* by Reichenow.

Rothschild has relegated the supposed subspecies *rufescens* to synonymy. I had written a long account of our large series of Chinese jays showing that "*rufescens*" has no region of its own, but occasionally turns up anywhere within the range of the variable *sinensis*. Briefly stated, our material wholly supports what Rothschild has said.

BIRDS FROM FOKIEN

PHASIANIDÆ

***Francolinus pintadeanus pintadeanus* (Scopoli)¹**

Four specimens, two males, two sex undetermined: Futsing, Fokien, June 1911 and 1912, and July 10, 1916. I think Scopoli's name must be used for the large bird of southern China, probably introduced from thence into Mauritius, with a wing ranging from 153 mm. to 157 mm., and the smaller form of Burma, Cochin China, Siam and Yunnan be known as *F. pintadeanus phayrei* (Blyth).

***Arboricola ricketti* Ogilvie-Grant**

Two specimens: a male, Yenping, Fokien, June 13, 1916; and one, sex undetermined, Futsing, Fokien, 1912.

***Bambusicola thoracica* (Temminck)**

Three adults, a male, and two females: Futsing, Fokien, April 1911 and March 17, 1912.

COLUMBIDÆ

***Streptopelia orientalis orientalis* (Latham)**

Three males: Futsing, Fokien, July 25 and August 1, 1916.

***Streptopelia chinensis chinensis* (Scopoli)**

One adult female: Futsing, Fokien, July 27, 1916.

RALLIDÆ

***Porzana pusilla pusilla* (Pallas)**

Two specimens, male and female: Futsing, Fokien, April and October 1912.

***Amaurornis akool coccineipes* Slater**

Four specimens, male, two females and one with sex not determined: Futsing, Fokien, May 1911, September 1912, and 1912.

***Gallicrex cinerea* (Latham)**

Three specimens, two adult males, one immature, sex not determined: Futsing, Fokien, June 1911.

¹For change of name from *Francolinus chinensis* to *F. pintadeanus* cf. Oberholser, 1919, Proc. Biol. Soc. Wash., XXXII, April, p. 21.

LARIDÆ***Sterna albifrons sinensis*** Gmelin

Two adults, male and female: Futsing, Fokien, May 1911.

Larus argentatus vegæ Palmén

One adult female: Futsing, Fokien, December 1912.

Charadriidæ***Arenaria interpres interpres*** (Linnæus)

Two specimens in winter plumage, sex undetermined: Futsing, Fokien, 1912.

Vanellus vanellus (Linnæus)

One adult, sex not determined: Futsing, Fokien, 1912.

Pluvialis dominicus fulvus (Gmelin)

One male, in winter plumage: Futsing, Fokien, October 1912.

Charadrius leschenaultii Lesson

One male: Futsing, Fokien, June 1911.

Charadrius alexandrinus dealbatus (Swinhoe)

One specimen, sex not determined: Futsing, Fokien, 1912.

Numenius arquatus lineatus Cuvier

One adult female: Futsing, Fokien, December.

Numenius phæopus variegatus (Scopoli)

Two specimens, one male, one sex not determined: Futsing, Fokien, 1912.

Tringa ochropus Linnæus

One adult female: Futsing, Fokien, July 21, 1916.

Heteractitis brevipes (Vieillot)

One female, in winter plumage: Futsing, Fokien, September 15, 1911.

Erolia ruficollis (Pallas)

Two females: Futsing, Fokien, May and June 1911.

Erolia acuminata (Horsford)

Three adults, male and two females, all in spring plumage: Futsing, Fokien, May 1911.

***Erolia alpina sakhalina* (Vieillot)**

Two specimens, sex not determined, in winter plumage: Futsing, Fokien, 1912.

***Gallinago gallinago gallinago* (Linnæus)**

One female: Futsing, Fokien, May 1911.

***Rostratula bengalensis bengalensis* (Linnæus)**

Two adults, male and female: Futsing, Fokien, May and June 1911.

GLAREOLIDÆ***Glareola maldivarum* Forster**

Three adults, two males and a female: Futsing, Fokien, May and June 1911.

ARDEIDÆ***Nycticorax nycticorax nycticorax* (Linnæus)**

One specimen, immature, sex not determined: Futsing, Fokien, 1912.

***Ardeola bacchus* (Bonaparte)**

Two specimens, an adult male and a somewhat immature female: Futsing, Fokien, July 25, 1916.

***Ixobrychus sinensis sinensis* (Gmelin)**

Two females: Futsing, Fokien, May 1911 and 1912.

***Ixobrychus cinnamomea* (Gmelin)**

Two adults, male and female: Futsing, Fokien, July 26 and 31, 1916.

ANATIDÆ***Melanonyx segetum serrirostris* (Swinhoe)**

One adult, sex not determined. Futsing, Fokien, 1912.

***Mergus serrator* Linnæus**

Four specimens, adult male and three females: Futsing, Fokien, November and December 19, 1912.

FALCONIDÆ***Astur soloensis*** (Horsfield)

Two specimens, adult male, and female immature: Futsing, Fokien, August 1913 and June 1914.

Accipiter gularis (Temminck and Schlegel)

One adult male: Futsing, Fokien, May 1911.

Buteo buteo japonicus (Temminck and Schlegel)

One male: Futsing, Fokien, October 1912.

Butastur indicus (Gmelin)

One adult, sex not determined: Futsing, Fokien, 1912.

Falco columbarius insignis (Clark)

One female: Futsing, Fokien, November 1912.

Cerchneis tinnunculus japonicus (Temminck and Schlegel)

Two females: Futsing, Fokien, January 1912 and 1912.

BUBONIDÆ***Otus bakkamoena glabripes*** (Swinhoe)

One immature female: Futsing, Fokien, July 24, 1916.

Ninox scutulata scutulata (Raffles)

Two adults, sex not determined: Futsing, Fokien, March 1912.

Glaucidium brodiei (Barton)

One adult, sex not determined (= male): Futsing, Fokien, 1912.

Glaucidium cuculoides whitelyi (Swinhoe)

Four specimens, one male, two females and one sex not determined: Futsing, Fokien, July 24 and 28 and August 1, 1916 and 1912.

CORACIDÆ***Eurystomus orientalis calonyx*** Sharpe

Three specimens, an adult female, and two young, male and female: Futsing, Fokien, April 1911 and August 1912. See Stresemann, 1913, Nov. Zool., XX, p. 299 for discussion of the geographical races and the points where intergradation takes place.

ALCEDINIDÆ***Ceryle lugubris guttulata* Stejneger**

Two males: Futsing, Fokien, July 27 and August 1, 1916.

***Alcedo atthis bengalensis* Gmelin**

Three specimens, two males and a female, all immature: Futsing, Fokien, July 12, 27 and 28, 1916.

***Halcyon amyrnensis fusca* (Boddaert)**

Five specimens, both sexes: Futsing, Fokien, July 26 and 28, 1916 and 1912.

***Halcyon pileata* (Boddaert)**

One female: Futsing, Fokien, July 31, 1916.

CAPRIMULGIDÆ***Caprimulgus indicus jota* Temminck and Schlegel**

Two females: Futsing, Fokien, 1912.

MICROPODIDÆ***Micropus pacificus pacificus* (Latham)**

Four specimens, three males, one with sex not determined: Futsing, Fokien, May and June 1911 and 1912.

TROGONIDÆ***Pyrotrogon erythrocephalus yamakanensis* Rickett**

One adult male: Yen-ping, Fokien, June 12, 1916.

CUCULIDÆ***Clamator coromandus* (Linnæus)**

Three adults, two males and a female: Yen-ping and Futsing, Fokien, June 12, 1916 and 1912.

***Cuculus optatus* Gould**

Three females: Futsing, Fokien, May 1911 and March and April 1912.

***Eudynamis orientalis chinensis* Cabanis and Heine**

Two adults, male and female: Futsing, Fokien, 1912.

Centropus bengalensis lignator Swinhoe

Three adults, male and female and one sex not determined: Futsing, Fokien, July 20, 23 and 24, 1916.

CAPITONIDÆ**Megalaema virens virens** (Boddaert)

Four adults, both sexes: Futsing, Fokien, July 27, 1916 and March 1912.

PICIDÆ**Picus canus ricketti** Stuart-Baker

Two adults, male and female: Futsing, Fokien, July 1916 and August 1912.

Dryobates cabanisi cabanisi (Malherbe)

Two males, one adult, one immature: Futsing, Fokien, October 1912 and July 26, 1916.

Micropternus brachyurus fokiensis (Swinhoe)

One adult male: Yenping, Fokien, June 12, 1916.

Jynx torquilla japonica Bonaparte

Three specimens, male and two with sex not determined: Futsing, Fokien, March 1912 and 1912.

HIRUNDINIDÆ**Hirundo rustica gutturalis** Scopoli

One immature male: Futsing, Fokien, July 3, 1916.

MUSCICAPIDÆ**Hemichelidon sibirica sibirica** (Gmelin)

One adult, sex not determined and without date of capture: Futsing, Fokien.

Pollomyias mugimaki (Temminck)

Four specimens, both sexes: Futsing, Fokien, 1912.

Cyanoptila cyanomelana Temminck

Seven specimens, both sexes: Futsing, Fokien, March 1912, September 1912, and 1912. The three adult males in this series are all black-throated birds with dark blue backs lined with black, and all be-

long to this form which seems to be specifically distinct from *C. cumatilis* Thayer and Bangs, the breeding bird of Central China.

***Hypothymis azurea styani* (Hartlaub)**

One (female): Futsing, Fokien, 1912.

***Tchitrea paradisi incii* Gould**

Three specimens, two males and a female, all in the brown phase of plumage: Futsing and Ling Sioh, Fokien, March 1912 and August 2, 1916.

***Tchitrea princeps princeps* (Temminck)**

One male: Futsing, Fokien, March 1912.

CAMPEPHAGIDÆ

***Volvocivora melanoptora* (Rüppell)**

Two males: Futsing, Fokien, April 1912.

***Pericrocotus griseigularis* Gould**

Two adult, male and female: Futsing, Fokien, June 1912 and 1912.

***Pericrocotus cantonenis* Swinhoe**

Four specimens, two adult males, an adult female and immature sex not determined: Futsing, Fokien, March 1912 and July 10, 1916. I do not use the genus *Motacilloides* Buturlin for the black, white and gray Minivets, as it does not seem to me worth while to subdivide the group.

PYCNONOTIDÆ

***Hypsipetes leucocephalus* (Gmelin)**

One immature (without white in the head) male: Futsing, Fokien, June 12, 1916.

***Hemixos canipennis* Seebohm**

Four adults, both sexes: Futsing and Ling Sioh, Fokien, July 27, 28, and 29, 1916, and April 1912.

***Iole maclellandi holti* (Swinhoe)**

Three specimens, one male, two females: Futsing and Ling Sioh, Fokien, July 28, 1916, and April 1912.

***Pycnonotus sinensis* (Gmelin)**

Twelve specimens, adult and immature of both sexes: Futsing, Fokien, July 3, 4, 22, 23, 24, 27, 28, and 31, 1916, and March 1912.

Spizixos semitorques Swinhoe

One adult, sex not determined: Futsing, Fokien, 1912.

TIMELIIDÆ**Lanthocincla canora** (Linnaeus)

Eight specimens, adult and immature, both sexes: Futsing, Fokien, July 10, 24, 27, and 28, 1916, and March 1912.

Pomatorhinus ruficollis stridulus Swinhoe

Eleven specimens, both sexes: Futsing, Fokien, July 1, 24, 26, and 31, 1916, and April 1912. These all have short bills, but the color of the back is variable in this series, some specimens being much less reddish than others.

Pomatorhinus swinhoei David

One adult male: Futsing, Fokien, 1912.

Garrulax picticollis Swinhoe

One male: Yenping, Fokien, June 15, 1916.

Dryonastes perspicillatus perspicillatus (Gmelin)

Four specimens, one adult, three immature: Futsing, Fokien, July 13 and 26, 1916, and March 1912.

Dryonastes sannio sannio Swinhoe)

Four specimens, two adult, two immature: Futsing, Fokien, July 26 and 27, 1916, and April 1912.

Alcippe nipalensis hueti (David)

Seven specimens, adults and immature of both sexes: Futsing, Fokien, July 26 and 31, 1916.

Hartert (Vog. Pal. fauna, p. 616) says he cannot substantiate the differences claimed by Styan to separate his *daridi* of Szechwan from true *hueti* of Fokien. In Harington's review of the genus published in 1915, however, both forms are kept. I have compared the present series with a large one in Mus. Comp. Zool. from Szechwan and find that the Fokien birds are decidedly paler below, the chest more pinkish, less grayish, the sides more buffy, less olivaceous and, therefore, consider *A. nipalensis daridi* Styan of Szechwan a good form.

Stachyrhidopsis ruficeps davidi Oustalet

Six specimens, adults and immature, both sexes: Futsing, Fokien, July 10, 26, and 29, 1916, and January 1912.

Myiophoneus cæruleus (Scopoli)

Four adult males: Futsing, Fokien, July 28, 1916, August and September 1912.

Staphidia torquola Swinhoe

One adult male: Yen-ping, Fokien, June 21, 1916.

TURDIDÆ**Turdus merula mandarinus** Bonaparte

Three females: Futsing, Fokien, March 1912.

Turdus cardis lateus Thayer and Bangs

Three adults, two males and a female: Futsing, Fokien, March 1912 and 1912.

Turdus eunomus Temminck

Four specimens, all unmarked as to sex: Futsing, Fokien, 1912.

Turdus hortulorum Scater

One adult male: Futsing, Fokien, 1912.

Turdus chrysolaus (Temminck)

Two females: Futsing, Fokien, April 1912.

Turdus aureus aureus Holander

Two specimens, a female and one with sex not determined: Futsing, Fokien, February 1912 and 1912.

Monticola solitarius pandoo (Sykes)

One adult male: Futsing, Fokien, March 1912.

Monticola solitarius philippensis (Müller)

Two males: Futsing, Fokien, 1912.

Monticola solitarius magna La Touche

Two specimens a male and a female: Futsing, Fokien, May 1911 and September 1912. These are large birds, apparently migrants of the big race that breeds in Northeast Siberia and Japan. The wing in the male gives 128 and in the female, 120 mm.

Enicurus sinensis Gould

Two males: Futsing and Ling Sioh, Fokien, July 27, 1916, and April 1912.

***Enicurus schistaceus* Hodgson**

Three adults, two males and a female: Futsing and Ling Sioh, Fokien, July 31, 1916, June 21, 1914, and June 1914.

***Chimarrhornis fuliginosa fuliginosa* (Vigors)**

One female: Futsing, Fokien, September 1912.

***Phonicurus aureus aureus* (Gmelin)**

One male: Futsing, Fokien, 1912.

***Ianthia cyanura* (Pallas)**

One male: Futsing, Fokien; no date of capture.

***Copsychus saularis saularis* (Linnæus)**

Eight specimens, adults of both sexes and one immature: Futsing, Fokien, July 4, 10, 23, and 24, 1916, and March 1912.

***Saxicola torquata stejnegeri* (Parrot)**

One female: Futsing, Fokien, 1912.

SYLVIIDÆ***Locustella ochotensis* (Middendorff)**

One specimen: Futsing, Fokien, May 1911.

***Sutoria sutoria phyllorrhaphea* Swinhoe**

Two males: Ling Sioh, Fokien, July 1 and 30, 1916.

***Cisticola cisticola tintinnabulans* (Swinhoe)**

Two specimens, male and female: Futsing, Fokien, May 1911.

LANIIDÆ***Lanius tigrinus* Drapiez**

One adult male: Futsing, Fokien, July 10, 1916.

***Lanius schach schach* (Linnæus)**

Six specimens, adults of both sexes and one immature female: Futsing and Ling Sioh, Fokien, July 22, 24, 27, and 28, 1916, and December 1912.

***Lanius cristatus lucionensis* Linnæus**

Three specimens, an adult male and two immature: Futsing, Fokien, May 1911, September 1912, and 1912.

PARIDÆ***Parus major commixtus* Swinhoe**

Five specimens, adults and immature: Futsing, Fokien, July 1, 10, 21, 23, and 24, 1916.

ZOSTEROPIDÆ***Zosterops palpebrosa simplex* Swinhoe**

Eleven specimens, both sexes: Futsing, Fokien, July 1, 3, 4, and 10, 1916, and October 1911 and 1912.

DICÆIDÆ***Dicæum ignipectus ignipectus* (Hodgson)**

Three specimens, a male and two females: Futsing, Fokien, 1911 and 1912.

MOTACILLIDÆ***Motacilla alba leucopsis* Gould**

Two specimens, an adult male and an immature female: Futsing, Fokien, July 24, 1916, and September 1912.

***Anthus hodgsoni* Richmond**

Two males: Futsing, Fokien, January and March 1912.

ALAUDIDÆ***Alauda gulgula cœlivox* Swinhoe**

One adult male: Futsing, Fokien, April 1912.

FRINGILLIDÆ***Eophona migratoria migratoria* Hartert**

Four adults, three males and a female: Futsing, Fokien, April 1912 and 1912.

***Chloris sinica sinica* (Linnæus)**

Two adult males: Futsing, Fokien, April 1912.

***Fringilla montifringilla* Linnæus**

Two specimens, sex not determined: Futsing, Fokien, 1912.

Possibly there may be an eastern subspecies, *Fringilla montifringilla subcuneolata* Kleinschmidt. But after carefully comparing long series of specimens from the far east with European birds, I find the only char-

acters claimed by Kleinschmidt—the size and distinctness of the paler marking of the outer tail feather—are very variable in both series and, in our material at least, do not indicate the existence of such a race.

***Passer montanus taiwanensis* Hartert**

Four specimens, two adult males, two immature males: Futsing and Ling Sioh, Fokien, July 28 and 31, 1916. I can refer these skins to no other form than *taiwanensis* originally described from Formosa. The adults have bills much larger than in *P. montanus saturatus* Stejn. of Japan and the Liu Kiu Islands. The culmen affording respectively 12.5 and 13 mm.

***Passer rutilans rutilans* (Temminck)**

Ten specimens, both sexes. Futsing, Fokien, July 1, 3, 4, 10, and 23, 1916, and January 1912.

***Emberiza spodocephala spodocephala* Pallas**

Two females: Futsing, Fokien, May 1911 and March 1912.

***Melophus melanicterus* (Gmelin)**

Three specimens, two males and a female: Futsing, Fokien, April and March 1912.

FLOCEIDÆ

***Munia punctata topela* Swinhoe**

Three adults, male and two females: Futsing and Ling Sioh, Fokien, July 26, 1916, January 20, 1914, and March 1912.

***Uroloncha squamicollis* Sharpe**

Ten adults, both sexes: Futsing and Ling Sioh, Fokien, July 26, 28, 29, 30, and 31, 1916.

STURNIDÆ

***Sturnia cineracea* (Temminck)**

Three specimens, both sexes: Futsing, Fokien, January 21, 1914, and 1912.

***Sturnia sinensis* (Gmelin)**

Two males: Futsing, Fokien, 1912.

***Sturnia violacea* (Boddaert)**

One adult male: Futsing, Fokien, May 1911. This example is a fine adult male in full spring plumage, and the record proves beyond doubt that the species does occasionally, at least, occur in China on migration.

***Æthiopsar cristatellus cristatellus* (Gmelin)**

Five specimens, adults of both sexes and one immature female: Futsing and Ling Sioh, Fokien, July 27 and 31, 1916, and March 1912.

ORIOLIDÆ***Oriolus indicus indicus* Jerdon**

Seven specimens, both sexes: Futsing, Fokien, July 4, 20, and 24, 1916, and March 1912.

DICRURIDÆ***Chibia hottentotta brevirostris* (Cabanis)**

One immature male: Ling Sioh, Fokien, August 2, 1916.

***Dicrurus leucogenys cerrussatus* (Bangs and Phillips)**

Four adults, both sexes: Futsing, Fokien, March and April 1912.

CORVIDÆ***Corvus coronoides levaillantii* Lesson**

One adult male: Futsing, Fokien, April 1912.

***Urocissa erythrorhyncha erythrorhyncha* (Gmelin)**

Nine specimens, adults and young of both sexes: Futsing and Ling Sioh, Fokien, July 24, 27, and 28, August 1, 1916, and March 1912.

***Dendrocitta formosæ sinica* Stresemann**

Two adult males: Futsing, Fokien, April 1912 and June 1914.

***Garrulus bispecularis sinensis* Swinhoe**

Four specimens, three adults, one immature, two marked as males, two without sex mark: Futsing, Fokien, January and April 1912.

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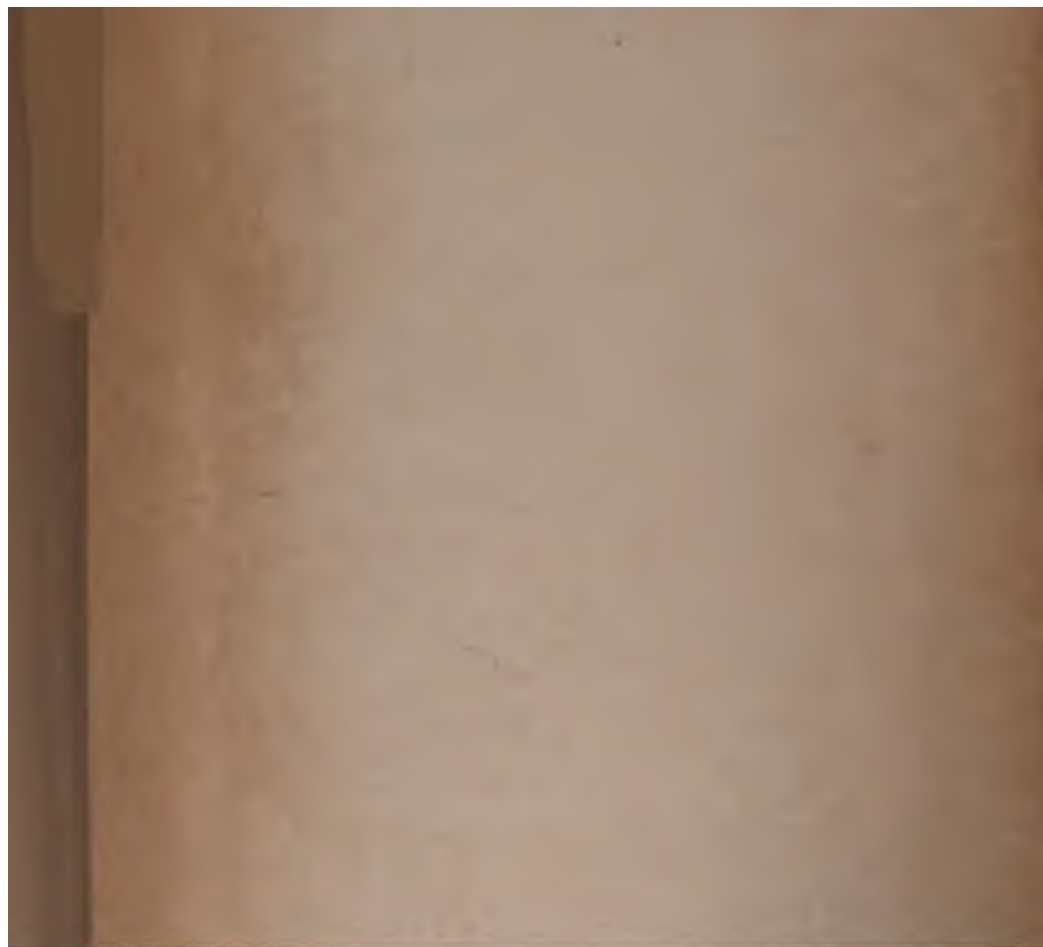
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